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TECHNICAL MANUAL

FREQUENCY METERS AN/URM--79 AND AN/URM--82

FR-4

PUBLISHED UNDER AUTHORITY OF THE SECRETARY OF THE AIR FORCE
AND THE SECRETARY OF THE ARMY

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TECHNICAL MANUAL
No. 11–5094
TECHNICAL ORDER
No. 16–35FR4–6

DEPARTMENTS OF THE ARMY AND
THE AIR FORCE
WASHINGTON 25, D. C., *30 December 1954*

FREQUENCY METERS AN/URM–79 AND AN/URM–82

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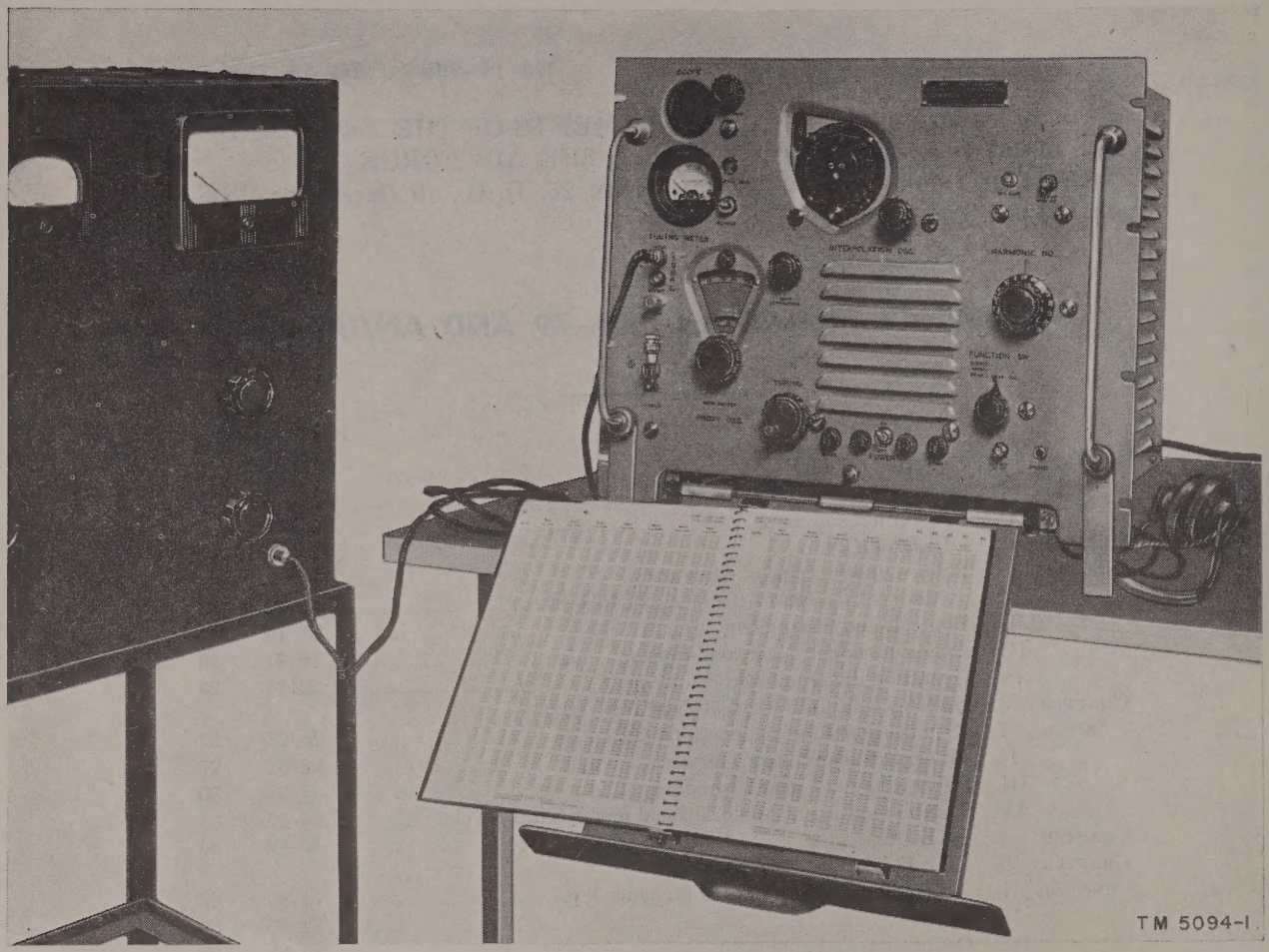

Figure 1. Frequency Meter FR–4/U in use as frequency meter.

CHAPTER 1
INTRODUCTION

Section I. GENERAL

1. Scope

a. This manual contains instructions for the installation, operation, maintenance, and repair of Frequency Meter AN/URM–79 and Frequency Meter AN/URM–82.

b. Frequency Meters AN/URM–79 and AN/URM–82 consist of Frequency Meter FR–4/U and various components and accessories. Frequency Meter FR–4/U is the major component of each unit. Figure 1 illustrates use of the Frequency Meter FR–4/U as a single unit. The nomenclature Frequency Meter AN/URM–79 is applied to the component grouping as supplied to the Signal Corps and Air Force (fig. 2); the nomenclature AN/URM–82 applies to the component grouping as supplied to the Navy (fig. 3).

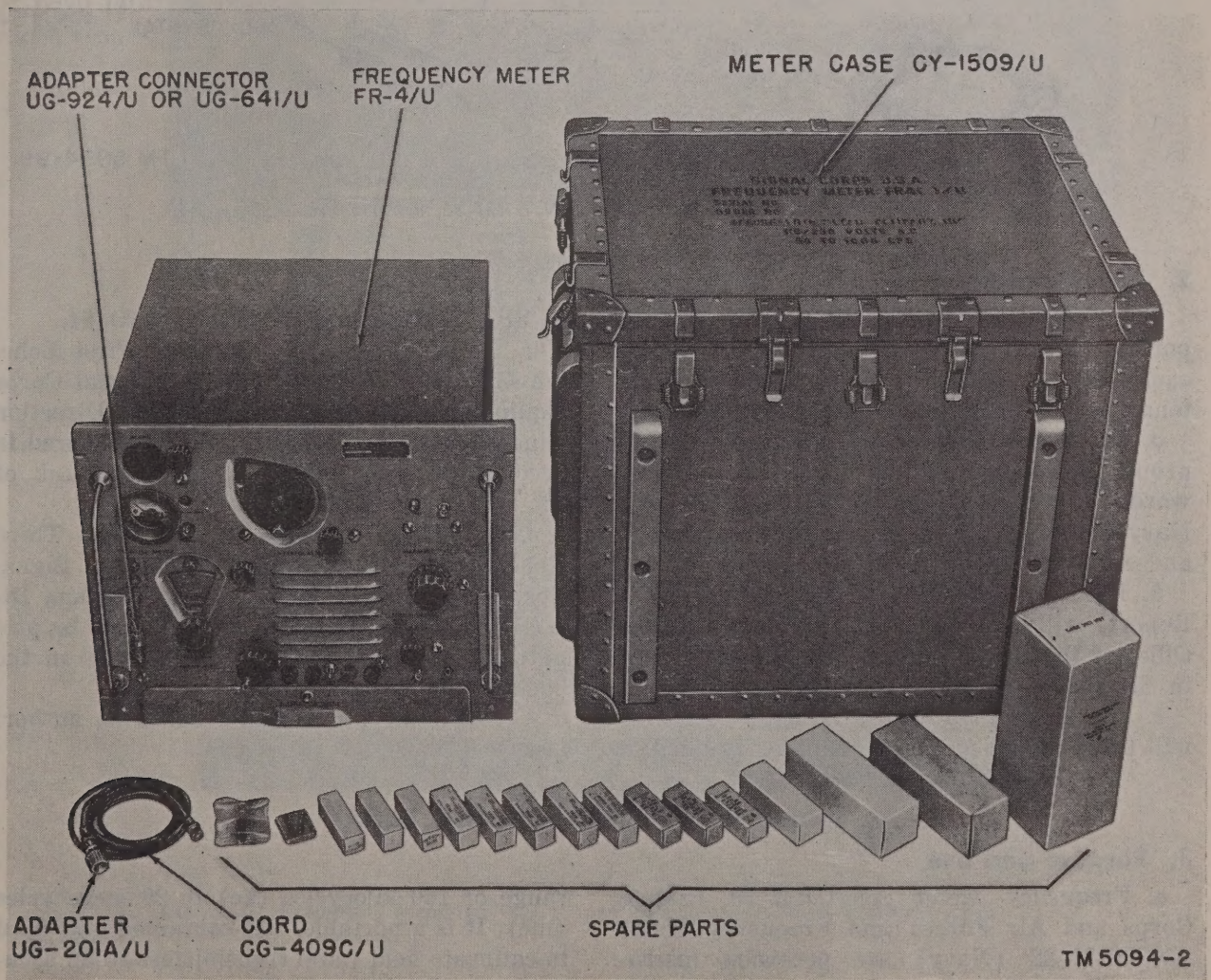

Figure 2. Frequency Meter AN/URM–79, components.

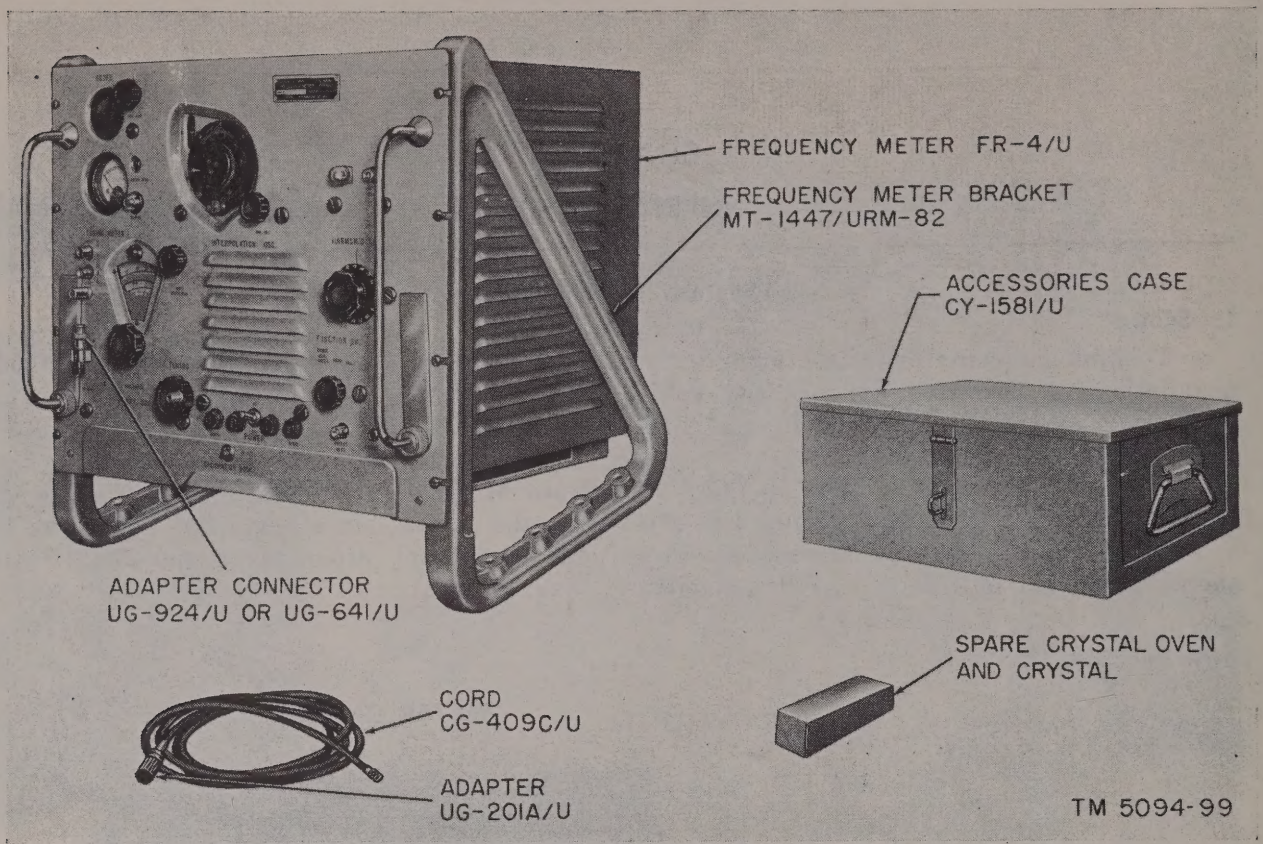

Figure 3. Frequency Meter AN/URM–82, components.

2. Forms and Records

The following forms will be used for reporting unsatisfactory conditions of Army equipment and in performing preventive maintenance:

a. DD Form 6 (Report of Damaged or Improper Shipment) will be filled out and forwarded as prescribed in SR 745–45–5 (Army), Navy Shipping Guide, Article 1850–4 (Navy), and AFR 71–4 (Air Force).

b. DA Form 468 (Unsatisfactory Equipment Report) will be filled out and forwarded to the Office of the Chief Signal Officer as prescribed in SR 700–45–5.

c. DD Form 535 (Unsatisfactory Report) will be filled out and forwarded as prescribed in SR 700–45–5 and AF TO 00–35D–54.

d. DA Form 11–238 (Operator First Echelon Maintenance Check List for Signal Corps Equipment (Radio Communication, Direction Finding, Carrier, Radar)) will be prepared in accordance with instructions on the back of the form.

e. DA Form 11–239 (Second and Third Echelon Maintenance Check List for Signal Corps Equipment (Radio Communication, Direction Finding, Carrier, Radar)) will be prepared in accordance with instructions on the back of the form.

f. Use other forms and records as authorized.

Section II. DESCRIPTION AND DATA

3. Purpose and Use

a. Frequency Meter AN/URM–79 (Signal Corps and Air Force) and Frequency Meter AN/URM–82 (Navy) are precision instruments designed to measure frequencies in the range of 100 kilocycles (kc) to 20 megacycles (mc). It is a portable, self-contained unit used to calibrate field radio transmitters to an accuracy of .001 percent. The major component,

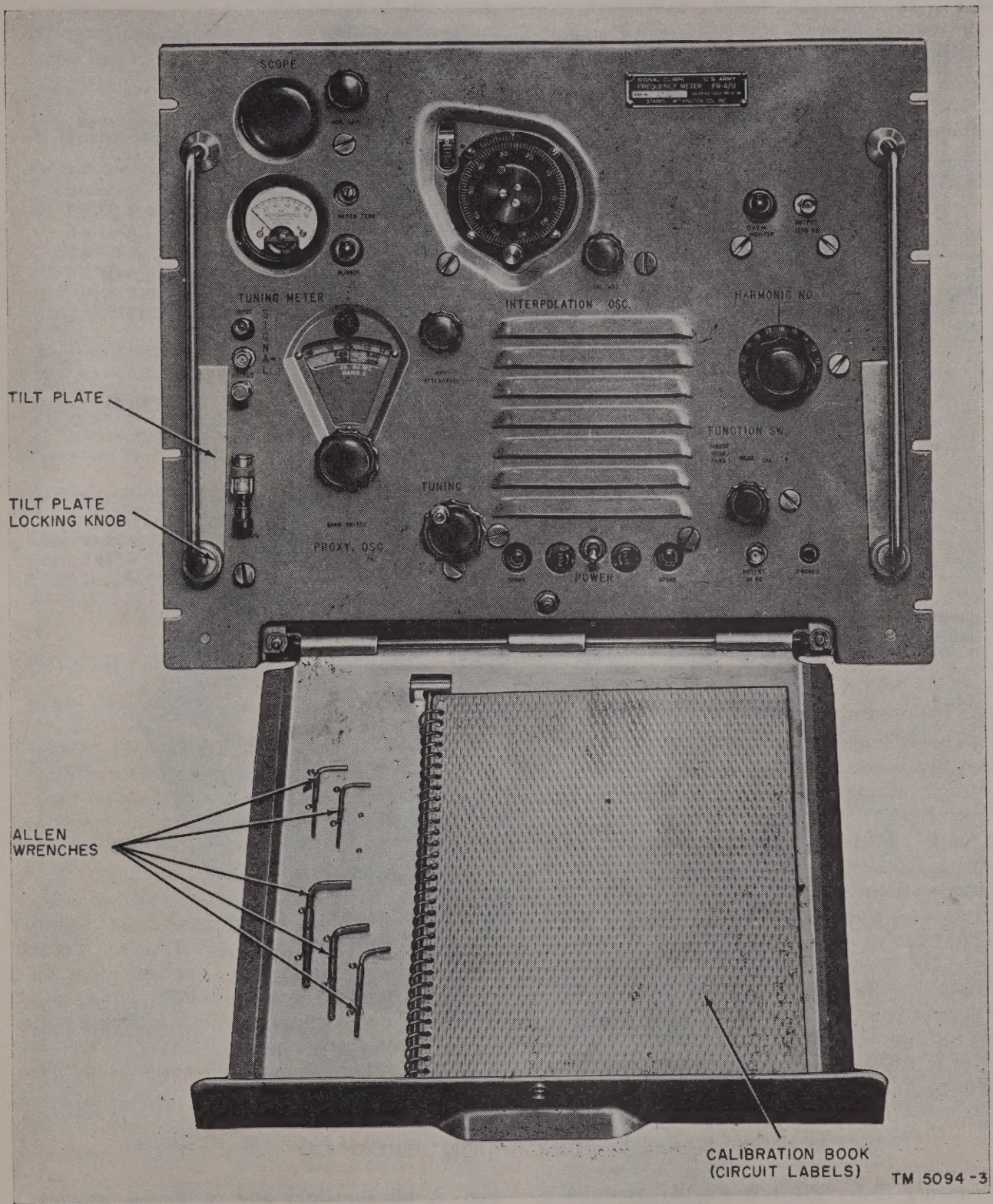

Figure 4. Frequency Meter FR-4/U, front view with calibration drawer open.

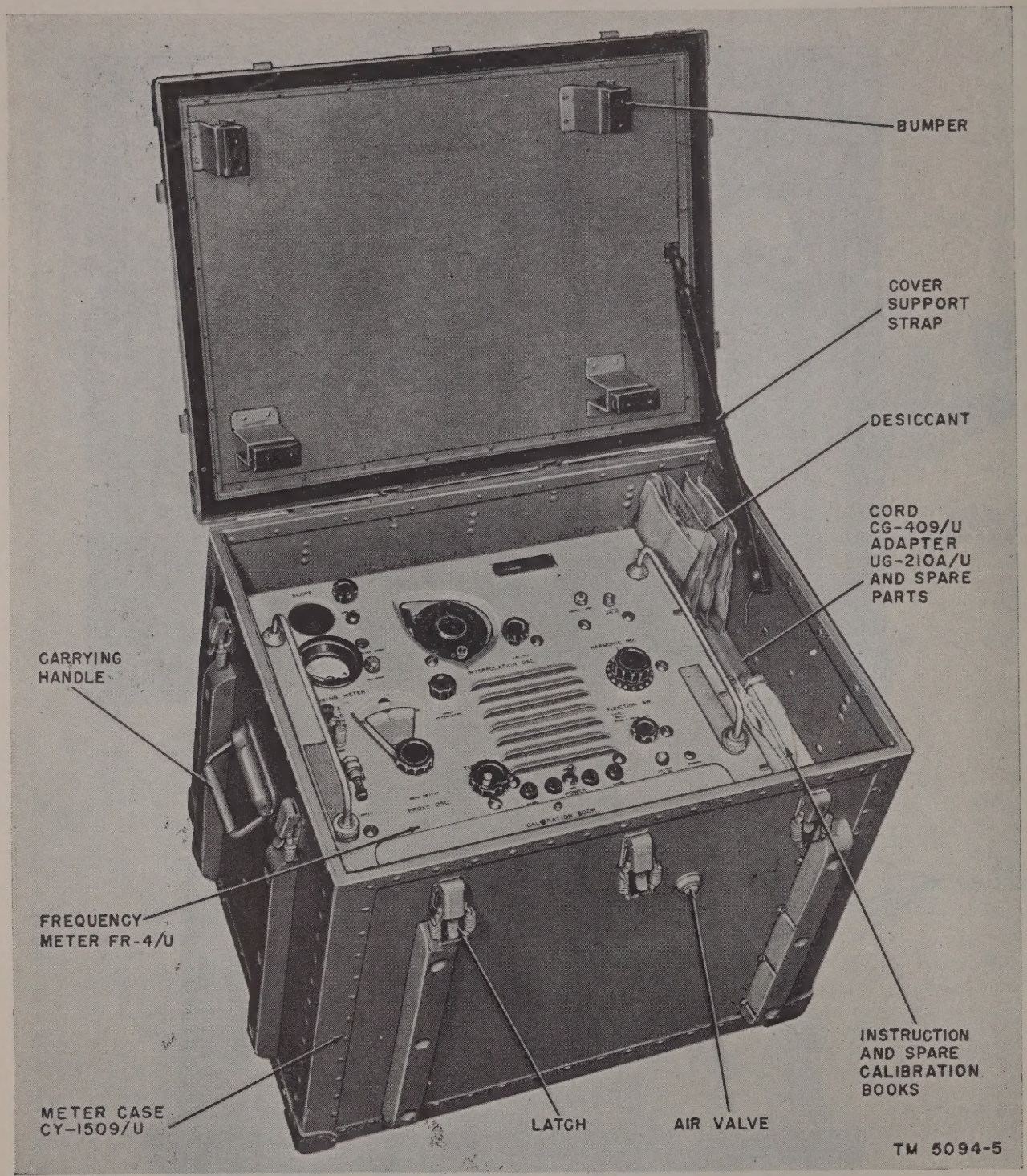

Figure 5. Components of Frequency Meter AN/URM-79 packed in Meter Case CY-1509/U.

Frequency Meter FR–4/U (fig. 4), contains a temperature stabilized crystal oscillator operating at 1,250 kc. This frequency then is divided to 10 kc, harmonics of which are used in making measurements and checking calibration. A blinker light and earphones provide visual and aural indications of zero beat settings. An oscilloscope, built into the FR–4/U, is used for interpolation.

b. The frequency meter also can be used as

a signal generator over the range of 100 kc to 20 mc. This instrument is useful in calibrating radio receivers.

4. Technical Characteristics

Frequency range:
- BAND 1 ..... 100–250 kc.
- BAND 2 ..... 250–500 kc.
- BAND 3 ..... 500–1,250 kc.
- BAND 4 ..... 1.25–2.5 mc.
- BAND 5 ..... 2.5–5 mc.
- BAND 6 ..... 5–10 mc.
- BAND 7 ..... 10–20 mc.

Oscillator frequencies:
- Proxy ..... 100–250 kc.
- Crystal ..... 1,250 kc.
- Blocking ..... 10 kc.
- Interpolation ..... 15–20 kc.

Frequency multiplication .... 2–80 times proxy oscillator frequency.
Harmonic selector ..... 9th through 26th harmonic of 10 kc.
Method of interpolation..... Built-in oscilloscope.
Crystal type ..... CR–36/U.
Calibration accuracy ..... .001 percent.
Rf output ..... 100 uv minimum (across 51 ohms on any harmonic).
Audio power output..... 1 mw minimum (across 600 ohms).
Power requirements..... 115 or 230 volts, 50–1,000 cps, 136 watts nominal.
Number of tubes..... 30.
Weight ..... 86 pounds.

5. Packaging Data

a. Frequency Meter AN/URM–79. When packaged for domestic shipment, Frequency Meter AN/URM–79 (fig. 5) is placed in a single corrugated carton. For export shipment, an outer wooden crate is added (fig. 6). The size, weight, and volume of the crate are indicated in the following chart:

Note. Items may be packaged in a manner different from that shown, depending on supply channels.

Crate No.	Height (in.)	Width (in.)	Depth (in.)	Volume (cu. ft.)	Unit weight (lb.)
1	22	26¼	20¾	6.9	155
Total weight					155

b. Frequency Meter AN/URM–82. Frequency Meter AN/URM–82 is shipped in two corrugated cartons (fig. 7). The two units of Frequency Meter Bracket MT–1447/URM–82 are assembled to Frequency Meter FR–4/U and the assembly is mounted to a wooden frame and placed in a corrugated carton. The size, weight, and volume of the cartons are indicated in the following chart:

Crate No.	Height (in.)	Width (in.)	Depth (in.)	Volume (cu. ft.)	Unit weight (lb.)
1	22	22⅝	21½	6.2	117.5
2	6⅜	13	10¼	.5	14
Total weight					131.5

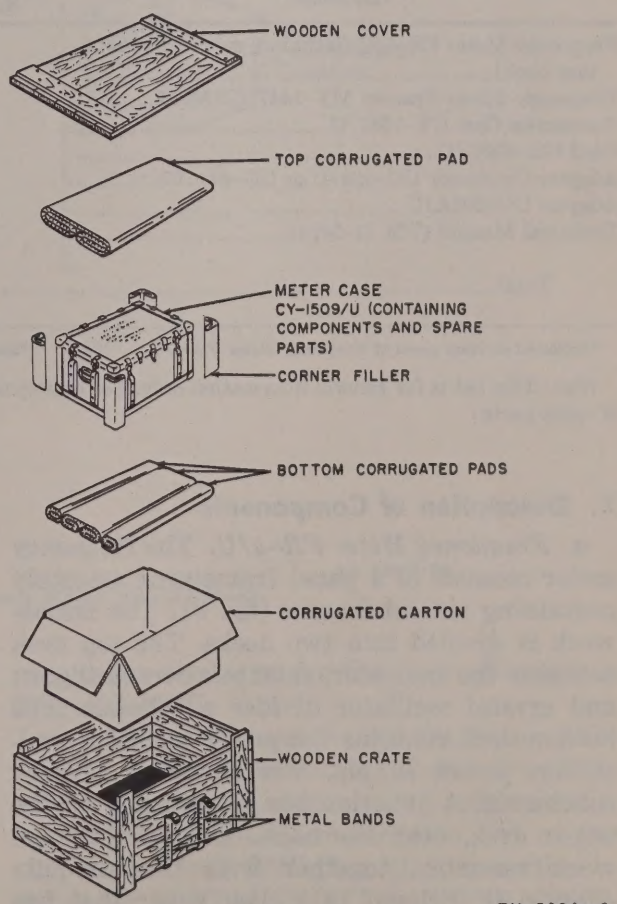

Figure 6. Packing Frequency Meter AN/URM–79.

6. Table of Components

a. Frequency Meter AN/URM–79.

Component	Required No.	Length (in.)	Width (in.)	Height (in.)	Volume (cu. ft.)	Weight (lb.)
Frequency Meter FR–4/U (including mounted calibration book)	1	19	18 1/8	15 3/4	3.14	86
Metcr Case CY–1509/U	1	26 1/8	20 3/4	22 7/8	7.03	60
Cord CG–409C/U	1	6			.015	
Adapter Connector UG–924/U or UG–641/U[1]	1					
Adapter UG–201A/U	1	1 9/16	3/4			
Technical Manual (TM 11–5094)	2	11	8 1/2	3/8		1 1/2
Total						147 1/2

[1]Mounted on front panel of Frequency Meter FR–4/U.

b. Frequency Meter AN/URM–82.

Component	Required No.	Length (in.)	Width (in.)	Height (in.)	Volume (cu. ft.)	Weight (lb.)
Frequency Meter FR–4/U (including mounted calibration book)	1	19	18 1/8	15 3/4	3.14	86
Frequency Meter Bracket MT–1447/URM–82	[2]1	[3]15 1/2	[3]3 3/4	[3]20		8 7/8
Accessories Case CY–1581/U	1	12 7/8	10 3/8	6 1/4	.48	6 3/8
Cord CG–409C/U	1	6			.015	
Adapter Connector UG–924/U or UG–641/U[1]	1					
Adapter UG–201A/U	1	1 9/16	3/4			
Technical Manual (TM 11–5094)	2	11	8 1/2	3/8		1 1/2
Total						102 3/4

[1]Mounted on front panel of Frequency Meter FR–4/U. [2]Pair. [3]Each.

Note. This list is for general information only. See appropriate supply publications for information pertaining to requisition of spare parts.

7. Description of Components

a. Frequency Meter FR–4/U. The frequency meter consists of a panel framework assembly containing six subchassis (fig. 8). The framework is divided into two decks. The top deck contains the indicator, interpolation oscillator, and crystal oscillator divider subchassis. The bottom deck contains the proxy oscillator-multiplier, power supply, and harmonic selector subchassis. A junction box is mounted on the upper deck, near the back. The panel-framework assembly, together with the six subchassis, is inclosed in a dust cover that has ventilating louvers on the sides and back. The operating controls and instruments are on the front panel (fig. 4). A pair of carrying handles with tilt plates attached to the lower studs are mounted on the front panel. Underneath the front panel is the calibration book drawer that tilts downward when fully extended. Five Allen wrenches are mounted in the drawer. The circuit labels are bound in the rear of the calibration book. The power cord, at the rear of the unit, is tucked into a shelf at the lower rear, below the dust cover, during transit or storage (fig. 8).

b. Cord CG–409C/U. Cord CG–409C/U consists of a 5-foot length of Radio Frequency Cable RG–58C/U with a Radio Frequency Plug

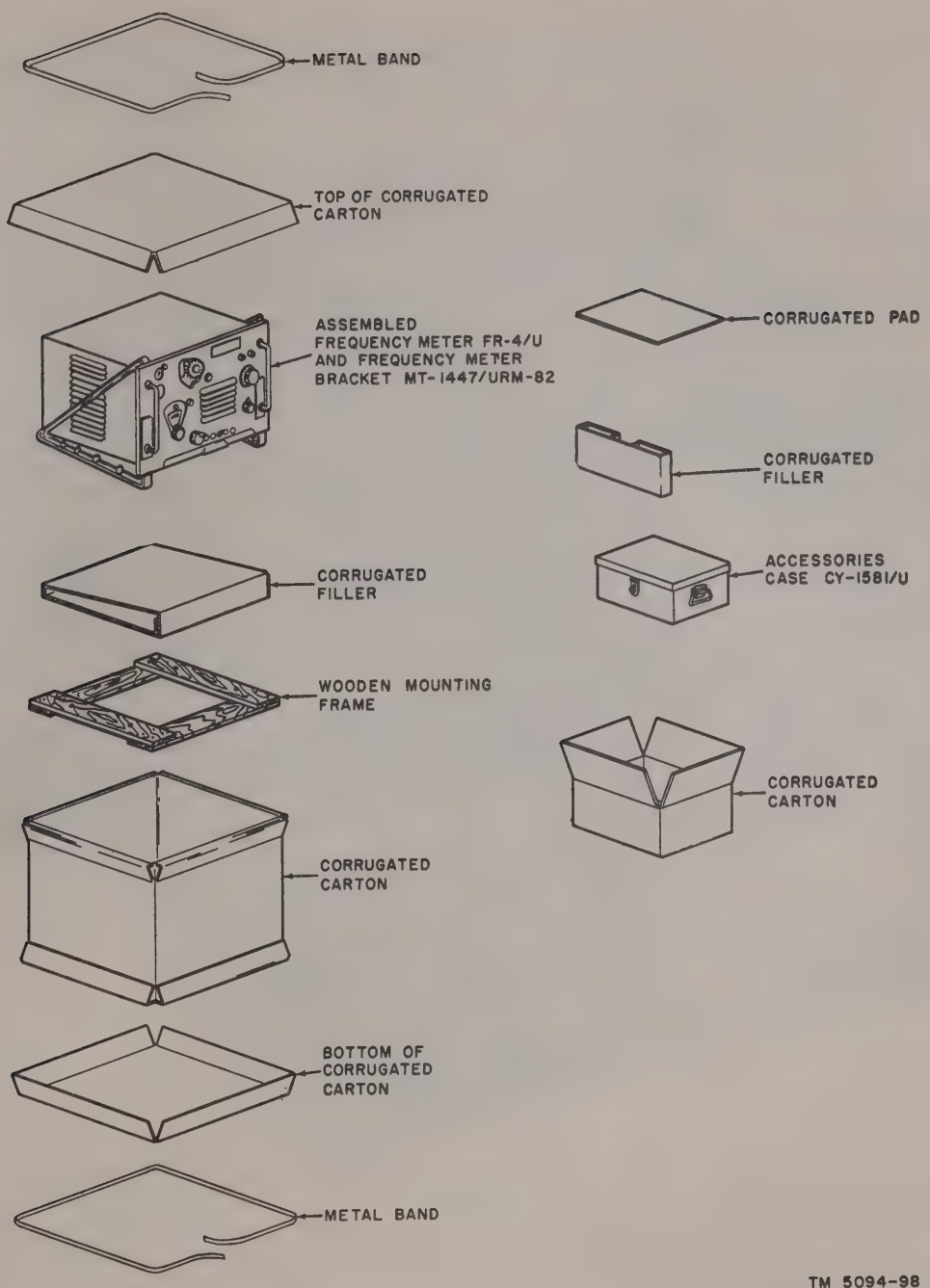

Figure 7. Packing Frequency Meter AN/URM-82.

UG–88/U at each end. This cable is used to connect the frequency meter to the unit under test. Adapter UG–201A/U is furnished for use with Radio Frequency Plug UG–88/U at the tested-unit end of the cable.

c. Adapter UG–201A/U. Adapter UG–201-A/U is furnished for use with Radio Frequency Plug UG–88/U at the test unit end of Cord CG–409C/U to permit connection to unit receptacles too large for the Radio Frequency Plug UG–88/U.

d. Adapter Connector UG–924/U or UG–641/U. Adapter Connector UG–924/U or UG–641/U permits connection of an unterminated lead to the frequency meter. One end of the adapter is a type BNC plug (for connection to either the SIGNAL INPUT or SIGNAL OUTPUT jack) ; the other end is a push-type bind-

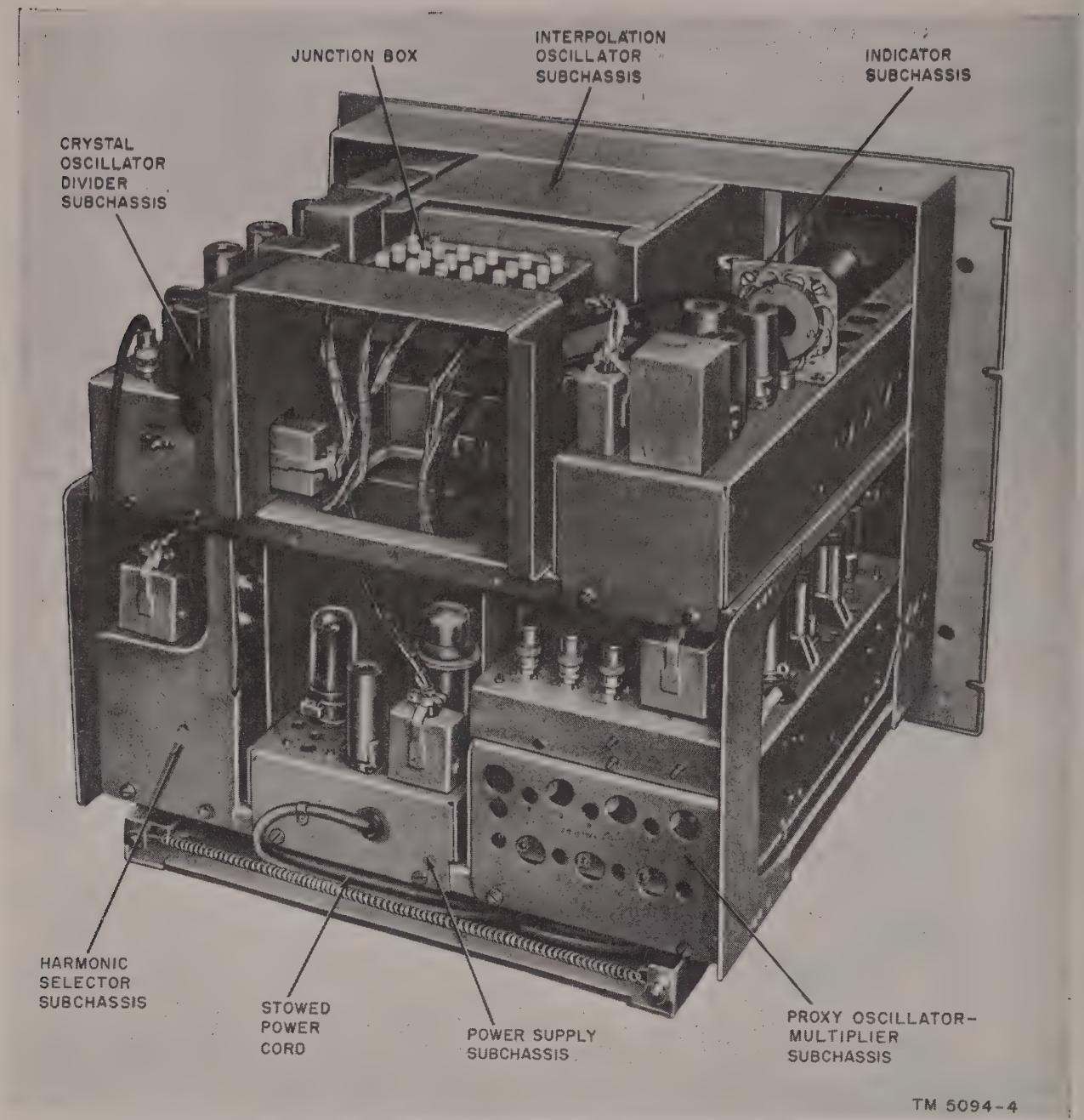

Figure 8. Frequency Meter FR–4/U, with dust cover removed.

ing point into which lead wire can be inserted.

e. Meter Case CY–1509/U. The components of the Frequency Meter AN/URM–79 are housed in Meter Case CY–1509/U (fig. 5). This case may be used for storage or transportation. The case is a metal-clad wooden case with a hinged top. The top is fastened down by means of latches. The latches on four sides are normally opened to allow the cover to swing on two hinge latches. The cover may be removed completely by releasing the rear latches and by unclipping the cover support strap at the cover. The frequency meter, when placed inside the case, is secured by bumpers to prevent damage from shock and vibration. There are carrying handles on the sides. An air valve on the front of the case permits equalization of inside and outside air pres-

sures; inside the case, a separate compartment contains the running spares for the equipment, technical manuals, rf cables, and bags of desiccant. Any field fabricated cables also may be stored in this compartment.

f. Accessories Case CY–581/U. In Frequency Meter AN/URM–82, Accessories Case CY–1581/U is used to store and ship Cord CG–409C/U with Adapter UG–201A/U attached, a spare crystal and crystal oven (assembled), a spare calibration book, and two technical manuals.

g. Frequency Meter Bracket MT–1447/URM–82. In Frequency Meter AN/URM–82, the two brackets that comprise Frequency Meter Bracket MT–1442/URM–82 are mounted to Frequency Meter FR–4/U (fig. 3) to provide firm bench mounting. The brackets in turn may be bolted to the bench using four holes in each bracket.

8. Running Spares

a. The following is a list of running spares supplied with Frequency Meter AN/URM–79. These items are stored in Meter Case CY–1509/U.

2 tubes, 6AU6.
1 tube, 6AH6.
3 tubes, 12AT7.
1 tube, 5654.
1 tube, 5725.
1 tube, 5670.
1 tube, 5751.
1 cathode-ray tube, 2BP1.
1 tube, OA2.
1 tube, 5Y3WGTA.
1 tube, 6Y6G.
5 fuses, Bussman type MDL, 2 amperes, 125 volts.
1 crystal and crystal oven, CR–36/U, assembled.
1 lamp, GE49.
1 lamp, GE328.
1 lamp, NE51.
1 calibration book.
2 technical manuals.
1 Adapter Connector UG–924/U or UG–641/U.

b. Spare Crystal Unit CR–36/U (1.25 mc) and crystal oven, CAL–953/K00000006, are furnished assembled with Frequency Meter AN/URM–82.

9. Additional Equipment Required

A pair of earphones is required for the operation of the frequency meter but is not supplied with the unit. The earphones should have an impedance of about 600 ohms; Headset HS–33 is satisfactory in this respect.

CHAPTER 2

OPERATION

Note. This chapter locates, illustrates, and furnishes the operator sufficient information pertaining to the controls and instruments for the proper operation of the equipment.

Section I. SERVICE UPON RECEIPT OF FREQUENCY METERS AN/URM–79 AND FREQUENCY METER AN/URM–82

10. Uncrating, Unpacking, and Checking New Equipment

Note. For used or reconditioned equipment, refer to paragraph 12.

a. General. Equipment may be shipped in oversea packing cases, in domestic packing cases, or in its own meter case. When new equipment is received, select a location where the equipment can be unpacked without exposure to the elements and which is convenient to the permanent or semipermanent installation of the equipment. Aside from checking to make sure that all equipment is present and undamaged, no special unpacking and uncrating procedures are necessary for equipment shipped in Meter Case CY–1509/U.

Caution: Be careful when uncrating, unpacking, and handling the equipment; carelessness may adversely affect the calibration.

b. Uncrating and Unpacking Export Shipments of Frequency Meter AN/URM–79 (fig. 6).

(1) Place the packing near the place where the equipment will be used.
(2) Cut and fold back the metal bands.
(3) Remove the top and one side of the packing case. Remove the nails with a nail puller. Do not attempt to pry off the sides and top; the equipment may be damaged.
(4) Remove the package from the wooden crate and place it on a workbench or near its final location.
(5) Remove the corrugated shipping carton and the corrugated pads and fillers from the meter case which contains the frequency meter, spare parts, rf cable assembly, and technical manual.
(6) If the meter case cover cannot be opened readily after release of the catches, unscrew the air valve on the front of the case (fig. 5) to equalize the outside and inside air pressures.
(7) Check the contents of the packing case against the master packing slip.

c. Unpacking Domestic Shipments of Frequency Meter AN/URM–79. The unpacking procedure for domestic packing cases is similar to that for export shipments with the exception that the wooden crate is not used and the corrugated carton is held by metal bands (*b* above and fig. 6). Check the contents of the packing case against the master packing list.

d. Unpacking Frequency Meter AN/URM–82 (fig. 7).

(1) Place the two cartons near the place where the equipment will be used.
(2) Cut and remove the metal bands from the larger carton.
(3) Remove the top of the carton, and remove the assembled Frequency Meter FR–4/U, Frequency Meter Bracket MT–1447/URM–82, and a wooden mounting frame.
(4) Remove the wooden mounting frame from the frequency meter brackets to free the filler located between the brackets and the base of the frequency meter.
(5) Cut and remove the metal bands from the smaller carton and open the carton.
(6) Remove and open Accessories Case CY–1581/U. Cord CG–409C/U and a spare crystal and crystal oven (assembled) are located in compartments of the case beneath the packages

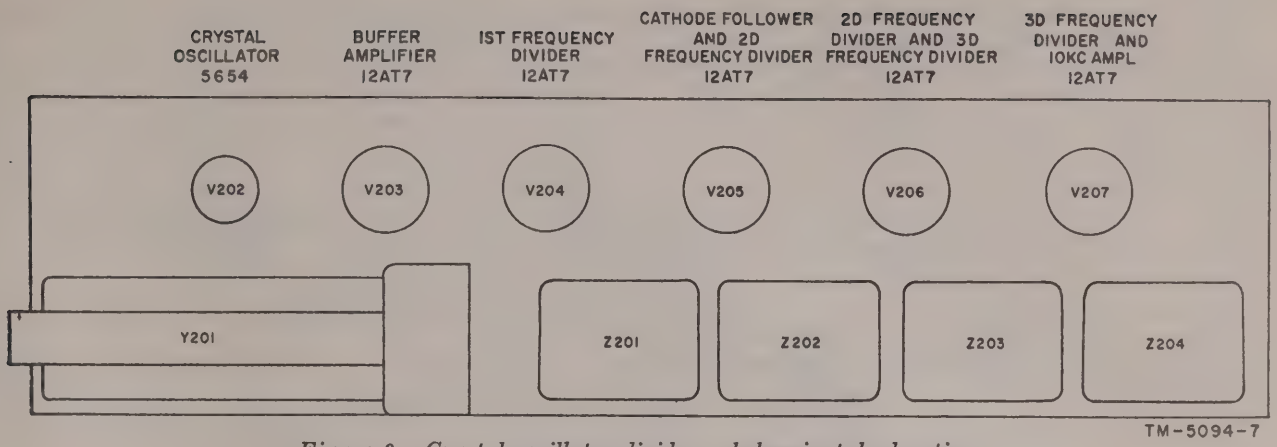

Figure 9. Crystal oscillator-divider subchassis, tube location.

containing technical manuals and a spare calibration book.

Note. Save the original packing cases and containers for both export and domestic shipments. They can be used again when the equipment is repacked for storage or shipment.

11. Installation of Equipment

a. Place the frequency meter close to the equipment being tested.

b. If desired, loosen each tilt plate locking knob (fig. 4), rotate the tilt plate until a detent sets the leg in the fully lowered position, and tighten the locking knob.

Caution: Unless otherwise tagged, the frequency meter is shipped with switch S602 (fig. 73) in 115-volt position. If the switch is set for 115-volt operation and the power cord is connected to a 230-volt outlet, the line fuses (on the front panel) will blow (POWER switch ON). On the other hand, if the switch is set for 230-volt operation and the power cord is connected to a 115-volt outlet, the line fuses will not blow but the equipment will be inoperative and the dial lamp will glow dimly.

c. Connect the power cord to a suitable power outlet (115 or 230 volts, 50 to 1,000 cycles per second (cps)). The cord is stowed in the compartment at a lower rear of the frequency meter (fig. 8).

d. To reset equipment for operation on 230-volt power source from operation on 115-volt power source (or vice versa), remove the power supply subchassis and reset switch S602.

(1) Disconnect the power cord.

(2) Remove the dust cover.

(3) Withdraw the two screws located on the outside of the two spare fuse holders on the front panel. Withdraw the two screws that hold the rear of the power supply subchassis to the chassis frame (fig. 8), then withdraw the subchassis.

Note. It is not necessary to disconnect the subchassis from the junction box.

(4) Turn the subchassis upside-down. Unscrew the switch lock from the toggle of switch S602 (fig. 73), reset the switch to the desired position as marked, and replace the lock.

(5) Reinstall the subchassis and dust cover.

(6) If switch S602 is set for 230-volt operation, *tag the equipment* accordingly.

e. Vacuum tubes are shipped in position on their respective subchassis. Proper installation of tubes may be checked against figures 9 through 14.

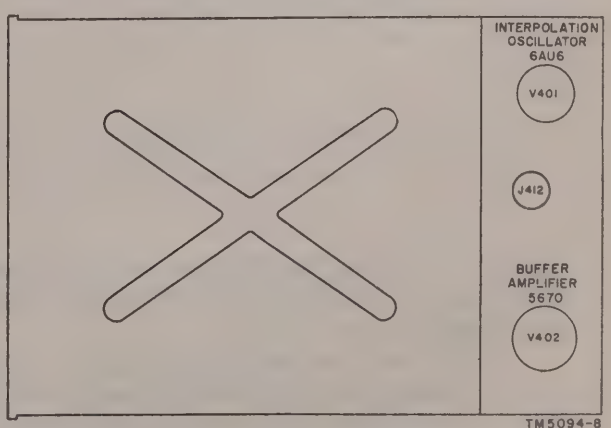

Figure 10. Interpolation oscillator subchassis tube.

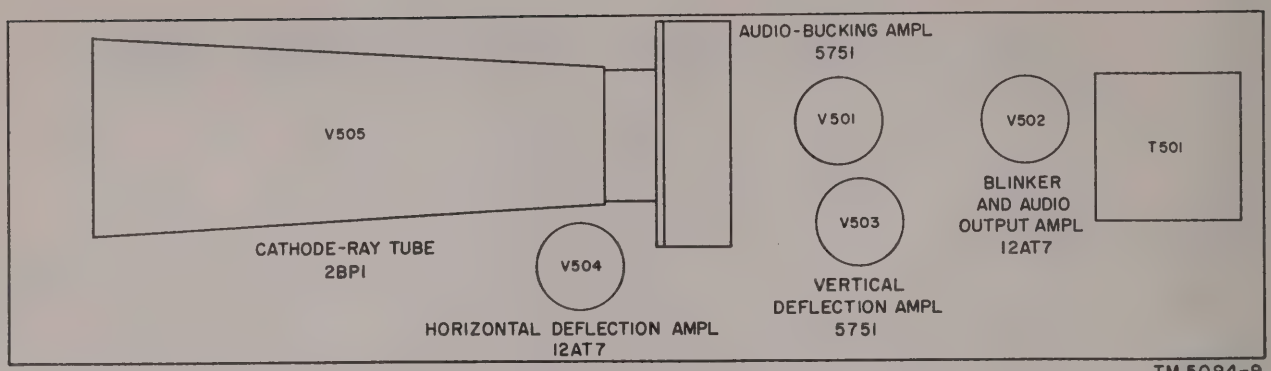

Figure 11. Indicator subchassis, tube location.

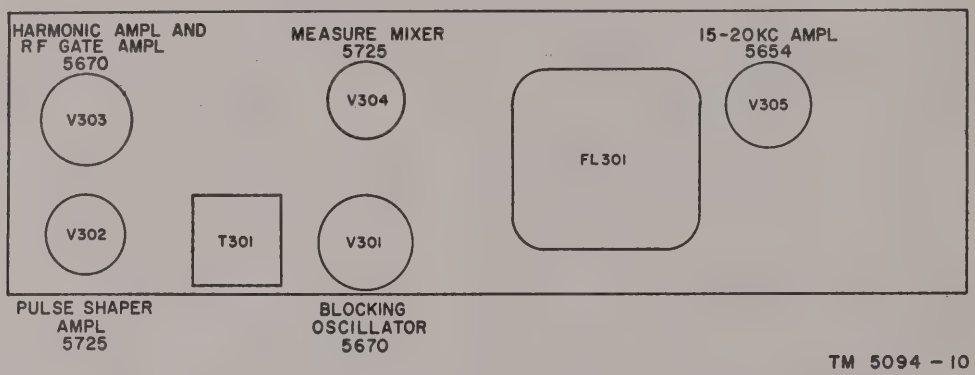

Figure 12. Harmonic selector subchassis, tube location.

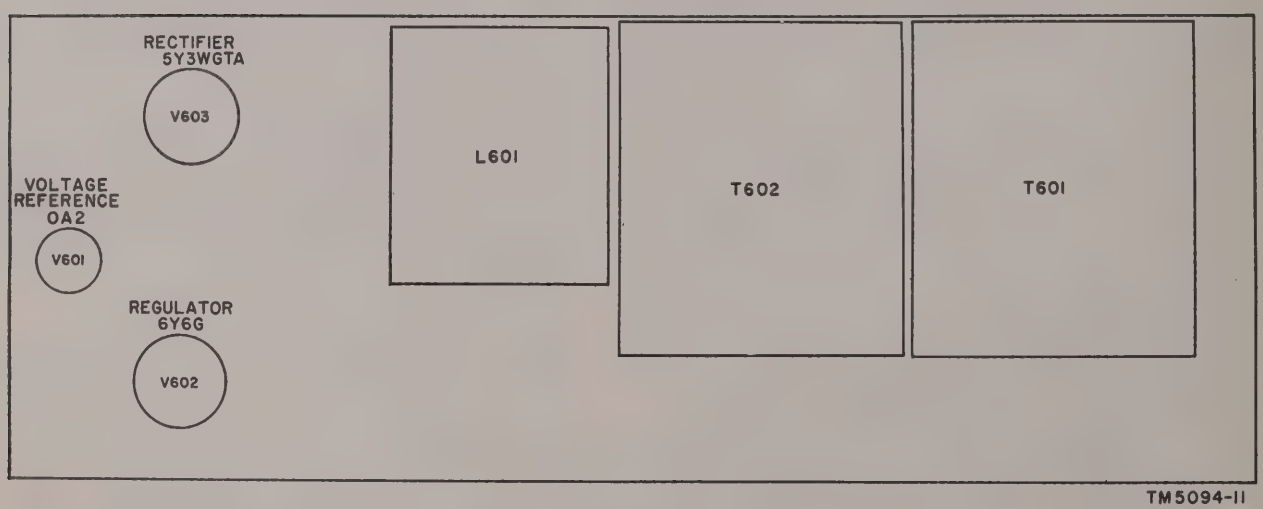

Figure 13. Power supply subchassis, tube location.

f. Connect the radio frequency (rf) cable between the frequency meter and the equipment under test.

(1) When the connection points of the equipment under test are type BNC connectors, use the normal terminations (UG–88/U) of the rf cable.

(2) When the connection points of the equipment under test are type N connectors, use Adapter UG–201A/U provided with the rf cable.

(3) When it is desired to couple to the equipment under test with an antenna, insert Adapter connector UG–924/U

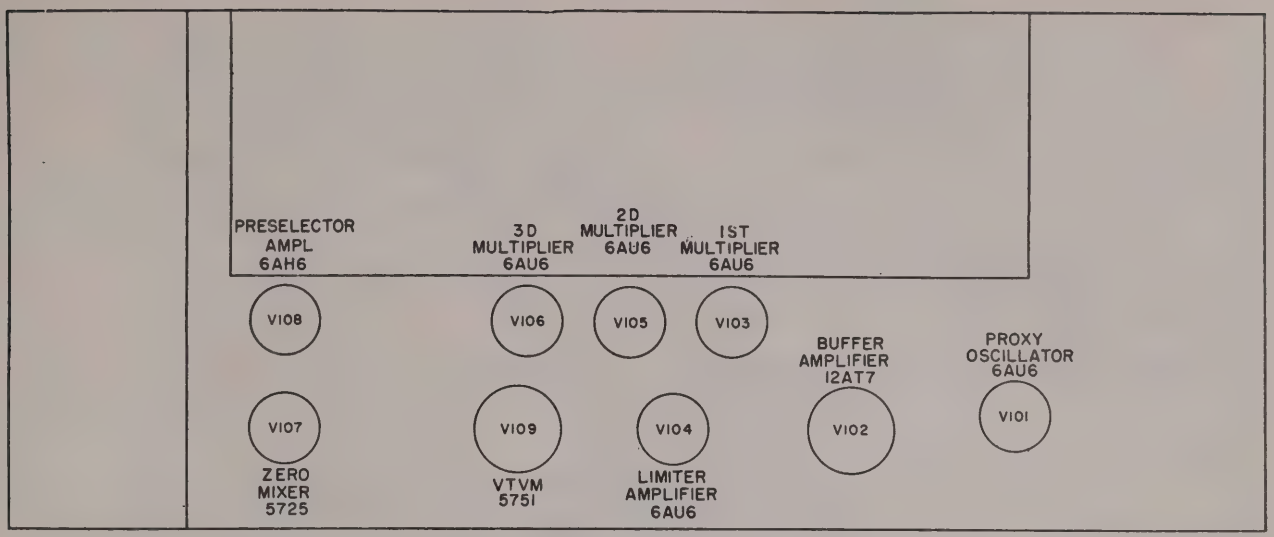

Figure 14. Proxy oscillator multiplier subchassis, tube location.

into the SIGNAL INPUT jack and connect a length of unshielded wire (2 or 3 feet long) to the adapter. Then the wire can be used as an antenna.

12. Service Upon Receipt of Used or Reconditioned Equipment

a. Follow the instructions in paragraph 10 for uncrating, unpacking, and checking the equipment.

b. Check used or reconditioned equipment for tags or other indications pertaining to changes in the wiring of the equipment. If any changes in wiring have been made, note the change in this manual, preferably on the schematic diagrams, and on the circuit labels found in the rear of the calibration book.

c. Check the operating controls for ease of rotation.

d. Perform the installation and connection procedure given in paragraph 11.

Section II. CONTROLS AND INSTRUMENTS

13. General

Haphazard operation or improper setting of the controls can cause damage to electronic equipment. For this reason, it is important to know the function of every control and indicator on the equipment. The function of the controls and indicators is described in paragraph 14. The actual operating instructions are contained in paragraphs 15 through 21.

14. Controls and Their Uses

The following chart lists the controls and instruments of the frequency meter (fig. 15) and indicates what they do:

Control	Function
POWER switch (S601)	In ON position, connects frequency meter to alternating-current (ac) power source.
BAND SWITCH (S101)	Selects desired frequency band. Has seven positions (one for each band):
	BAND 1 .1– .25 mc
	BAND 2 .25– .5 mc
	BAND 3 .5–1.25 mc
	BAND 4 1.25–2.5 mc
	BAND 5 2.5–5 mc
	BAND 6 5–10 mc
	BAND 7 10–20 mc
PROXY. OSC. TUNING control (C101 and C104).	Controls tuning of proxy oscillator, frequency multipliers, and preselector amplifier. Rotation of dial knob tunes frequency meter to unknown frequency to obtain zero beat. Dial indicates harmonic number, color, and coarse frequency (par. 18).

Control	Function
INPUT ATTENUATOR control (R144).	Adjusts amplitude of unknown frequency input signal fed to preselector amplifier.
SIGNAL INPUT jack (J106).	Provides connection for rf cable (carrying unknown frequency) to frequency meter.
SIGNAL OUTPUT jack (J103).	Provides connection for output signals over range of 100 kc to 20 mc (when frequency meter is used as signal generator).
GNC. jack	Provides ground connection to external units.
TUNING METER (M501).	Facilitates adjustment of frequency meter to unknown frequency.
METER ZERO control (R539).	Zeroes TUNING METER.
BLINKER light (I 501).	Provides visual indication of zero beat (neon lamp).
SCOPE cathode-ray tube (V505).	Provides visual means of comparison between frequencies of interpolation oscillator and output of 15- to 20-kc amplifier and interpolation oscillator frequency and harmonic of 10 kc for calibration of interpolation oscillator.
HOR. GAIN control (R536).	Adjusts signal amplitude to cathode-ray tube horizontal deflection circuit (signal may come from either harmonic amplifier (CAL.) or 15- to 20-kc amplifier (MEAS.)).
INTERPOLATION OSC. dial (hundreds).	Drum dial on shaft of interpolation oscillator tuning capacitor. It is graduated into 50 equal divisions. Reading of each division is multiplied by 100.
INTERPOLATION OSC. dial (units).	Disk dial geared to hundred dial above. Graduated in 100 equal divisions. Reading of each division is multiplied direct. Vernier dial provides readings in tenths. One complete revolution of units dial moves hundreds dial through one division.
CAL. ADJ. control (C402).	Facilitates calibration of interpolation oscillator (vernier-tuning capacitor).
OUTPUT 1250 KC jack (J219).	Provides connection for measuring crystal oscillator frequency.
HARMONIC NO. switch (S303).	Selects harmonics of 10 kc ranging from 9th to 26th harmonic (18-position switch). Harmonic to be used is read from proxy oscillator dial.
FUNCTION SW. (S301)	In CAL. position, feeds selected harmonic of 10 kc to oscilloscope for calibration of interpolation oscillator. In MEAS. position, permits indirect method of frequency measurement using proxy oscillator output. In DIRECT MEAS. BAND 1 position, permits use of unknown frequency instead of proxy oscillator output for measurement.
OUTPUT 10 KC jack (J318).	Provides connection for 10-kc pulse output.
PHONES jack (J310)	Provides connection for earphones for audible indication of zero beat.

Section III. OPERATION UNDER USUAL CONDITIONS

15. Starting Procedure

a. Before operating the frequency meter, the POWER switch should be at the OFF position.

Caution: Check for tags indicating proper voltage for the frequency meter.

b. Plug the power cord into a proper power source.

c. To energize the equipment, snap the POWER switch to the ON position. The PROXY. OSC. dial lamp should light. The OVEN HEATER lamp should light brightly, then cycle on and off dimly.

Note. Allow a minimum warmup time of 20 minutes before using the frequency meter.

16. Preoperating Procedure

The preoperating procedures are performed after the equipment is energized but before the equipment is operated. These adjustments are made only as required.

a. Adjust focus control R526 (fig. 69) on the indicator subchassis for sharpest focus.

b. Adjust intensity control R527 (fig. 69) on the indicator subchassis for the desired brightness.

Note. It may be necessary to readjust the focus control after adjusting the intensity control. Do not turn the intensity control too far up as it may make focusing difficult.

c. Adjust volume expansion control R505 (fig. 69) on the indicator subchassis until a spurious signal detected on the earphones is at its lowest volume.

d. Adjust the METER ZERO screwdriver control on the front panel until the meter needle falls on the zero marking. Make this adjustment with the INPUT ATTENUATOR

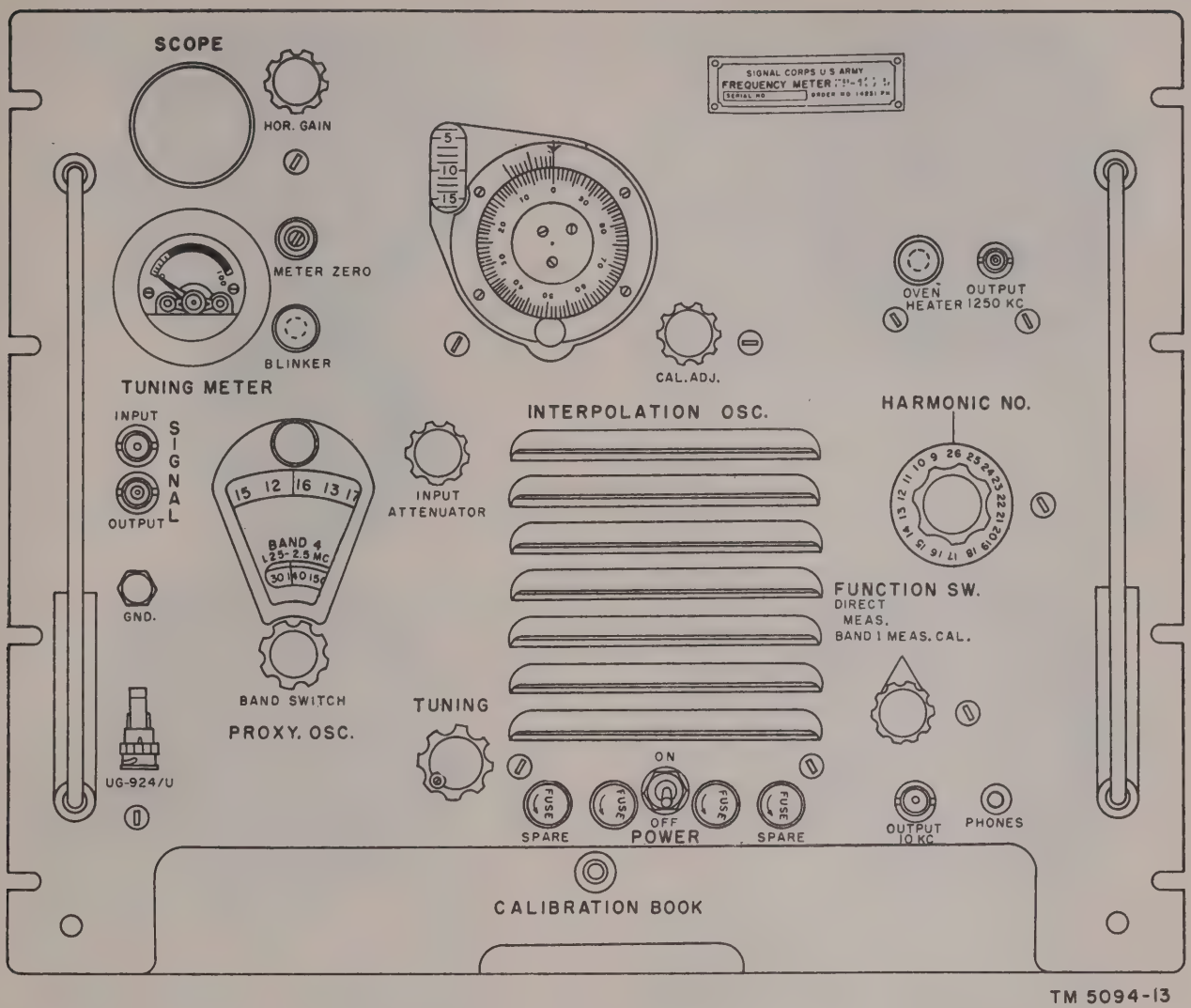

Figure 15. Frequency Meter FR–4/U, front panel controls and instruments.

control turned fully counterclockwise. To make sure that the frequency meter is not picking up strong signals from nearby equipment while this adjustment is being made, turn the TUNING control through its range. If the meter needle moves from its zero position, outside signals are being picked up. The meter must be readjusted to zero and again a check must be made to see that no stray signals are being picked up.

17. Types of Operation

a. Operation as Frequency Meter on All Bands.

(1) Couple the equipment under test to the SIGNAL INPUT jack (fig. 15) by means of the rf cable or by Adapter Connector UG–924/U or Adapter UG–201A/U.

(2) Set the FUNCTION SWITCH to MEAS.

(3) Turn the BAND SWITCH to the appropriate band.

Note. If the range of the frequency being measured is not known, search for the proper frequency; turn the BAND SWITCH to BAND 1 and, starting at the lowest frequency (100 kc), vary the TUNING control in the direction of increasing frequency. If necessary, repeat this procedure on the other bands until the unknown frequency is located by zero-beating as described below. As a quick way of determining the band into which the unknown frequency falls, use the front panel meter first as follows:

(4) Turn the INPUT ATTENUATOR fully clockwise (minimum attenuation).

(5) Adjust the TUNING control to obtain a meter deflection within the green band on the meter. If necessary, adjust the INPUT ATTENUATOR to prevent overloading of the metering circuit and to give a deflection within the green band. After proper adjustment of the INPUT ATTENUATOR, the TUNING METER should indicate a *definite peak reading* as the tuning control is adjusted.

(6) Plug the earphones into the PHONES jack.

(7) Using the earphones, make a fine adjustment of the TUNING control by listening for zero beat. When the tuning approaches the region of zero beat from either direction, the frequency of sound heard on the earphones decreases until it is no longer audible. This is the point of zero beat. For a more accurate setting of zero beat, use the BLINKER neon light. In the region of zero beat, the light will remain off or blink on and off at a very slow rate.

Note. At the higher bands, it may not be possible to adjust the tuning for a very slow blinking rate. In this case, the BLINKER light should blink at the slowest possible rate.

(8) Turn the HARMONIC NO. selector switch to the harmonic number indicated on the PROXY. OSC. dial. If the PROXY. OSC. dial setting falls between two harmonic numbers, refer to paragraph 18.

(9) Adjust the INTERPOLATION OSC. dial until a single closed Lissajous pattern (fig. 16) appears on the SCOPE. Note the dial reading.

Note. Activation and deactivation of the crystal OVEN HEATER as evidenced by the OVEN HEATER lamp may cause a phase shift in the frequency divider circuits. This will cause the pattern displayed on the oscilloscope to jump. If the pattern is stationary during the intervals when the OVEN HEATER lamp is either ON or OFF, the adjustment is correct.

(10) In the calibration book, locate the interpolation oscillator reading in the *Dial Div* column corresponding to the value obtained in (9) above. Calibration data applicable only to the readings on that page appear at the bottom of each page.

Note. Instructions for reading the INTERPOLATION OSC. dial are given in paragraph 19.

Figure 16. Lissajous pattern, 1:1 ratio.

(11) Turn the FUNCTION SW. from MEAS. to CAL.

(12) Refer to the data at the bottom of the calibration book page on which the proper dial division reading is located, and turn the INTERPOLATION OSC. dial to the setting shown as the crystal check point dial division. Set the HARMONIC NO. selector switch to the harmonic number shown at the bottom of the page. A stationary Lissajous pattern ratio, indicated at the bottom of the page, should appear on the SCOPE. For typical calibration Lissajous patterns, refer to figure 17. If the correct pattern does not appear, adjust the CAL. ADJ. control until it does. The interpolation oscillator now is calibrated.

(13) Return the HARMONIC NO. selector switch to the harmonic number indicated on the PROXY. OSC. dial ((8) above).

(14) Return the FUNCTION SW. to MEAS.

(15) Adjust the INTERPOLATION OSC. dial until a single closed Lissajous pattern appears on the SCOPE. Note the dial reading.

5:1

7:1

9:1

11:1

13:1

15:1

NOTE:
FUNCTION SW. IN CAL. POSITION.

TM 5094-15

Figure 17. Sample Lissajous pattern ratios used in calibration.

(16) Refer to the calibration book (par. 20) to locate the reading in the *Freq Cycles* column corresponding to the dial reading obtained in (15) above. Read the value under the correct band and in the color corresponding to the dial marking. Add this value to the frequency marked on the PROXY. OSC. dial to the *left* of the harmonic number used. (The PROXY. OSC. dial reading first must be converted to a value in cycles). The sum obtained is the unknown frequency.

b. Alternate Operation as Frequency Meter (Band 1 only). Frequencies from 100 to 250 kc (bands) may be measured more accurately by substituting the unknown signal for the proxy oscillator signal. Perform the zero beating operation with the FUNCTION SW. at MEAS. (*a.* (1) through (7) above). Once the zero beating operation is performed, turn the FUNCTION SW. to DIRECT MEAS. BAND 1. Proceed as directed in *a* (8) through (16) above.

c. Operation as Signal Generator.

(1) Couple the equipment under test to the SIGNAL OUTPUT jack by means of the rf input cable or Adapter Connector UG–924/U or UG–641/U.

(2) Set the FUNCTION SW. to MEAS.

Note. The following procedure is required to select an output frequency of 102,940 cps. For other frequencies, follow the procedure indicated substituting the actual frequency desired.

(3) Turn the BAND SWITCH to the band that includes the desired frequency, in this example, *Band 1.*

(4) Using the TUNING control, set the PROXY. OSC. dial to the approximate desired frequency. For the given example, the dial hairline will indicate about 103,000 cps.

(5) Convert the frequency that appears to the left of the hairline to cps. In this example, the frequency is 100,000 cps.

(6) Subtract the frequency obtained in (5) above from the desired frequency. For this example, subtract 100,000 from 102,940 to obtain the difference frequency of 2,940 cps.

(7) Referring to the calibration book, find the page containing the difference frequency in the black or red column of the proper band. In the example, 2,940 cps will be found in the black column under *Band 1.* At the bottom of this page, note the crystal calibration data.

(8) Calibrate the interpolation oscillator as described in *a* (11) and (12) above.

(9) After calibrating the interpolation oscillator, return the FUNCTION SW. to MEAS.

(10) Set the interpolation oscillator to the dial setting appearing in the *Dial Div* column opposite the *Freq. Cycles* reading. In the example, the dial setting is the number in the *Dial Div* column opposite 2,940 cps in the black column of *Band 1.*

(11) Set the HARMONIC NO. selector switch to the harmonic number indicated in the uppermost scale of the PROXY. OSC. dial. In this example, the harmonic number is 12.

Note. If the hairline falls between two harmonic numbers, choose the number that has the same color as that of the column in which the difference frequency was found in (7) or (10) above.

(12) Rotate the PROXY. OSC. dial slowly in the vicinity of the setting made in (4) above until a stationary single-loop Lissajous pattern (fig. 16) appears on the SCOPE. The frequency meter now is operating as a signal generator, generating a frequency of 102,940 cps.

18. Reading PROXY. OSC. Dial

a. The PROXY. OSC. dial (fig. 18) is a direct reading type. Three types of information can be obtained from the dial.

(1) The lower sector of the dial provides a coarse indication of the unknown frequency. In BAND 1 position, the dial graduations are in 10-kc divisions; on the remaining bands (2 through 7), the dial graduations are in multiples of 10 kc.

(2) The upper sector of the dial indicates a harmonic number used to set the HARMONIC NO. selector switch.

(3) The harmonic number appears in black or red. The color of the number is used in reading the calibration book for the interpolation oscillator.

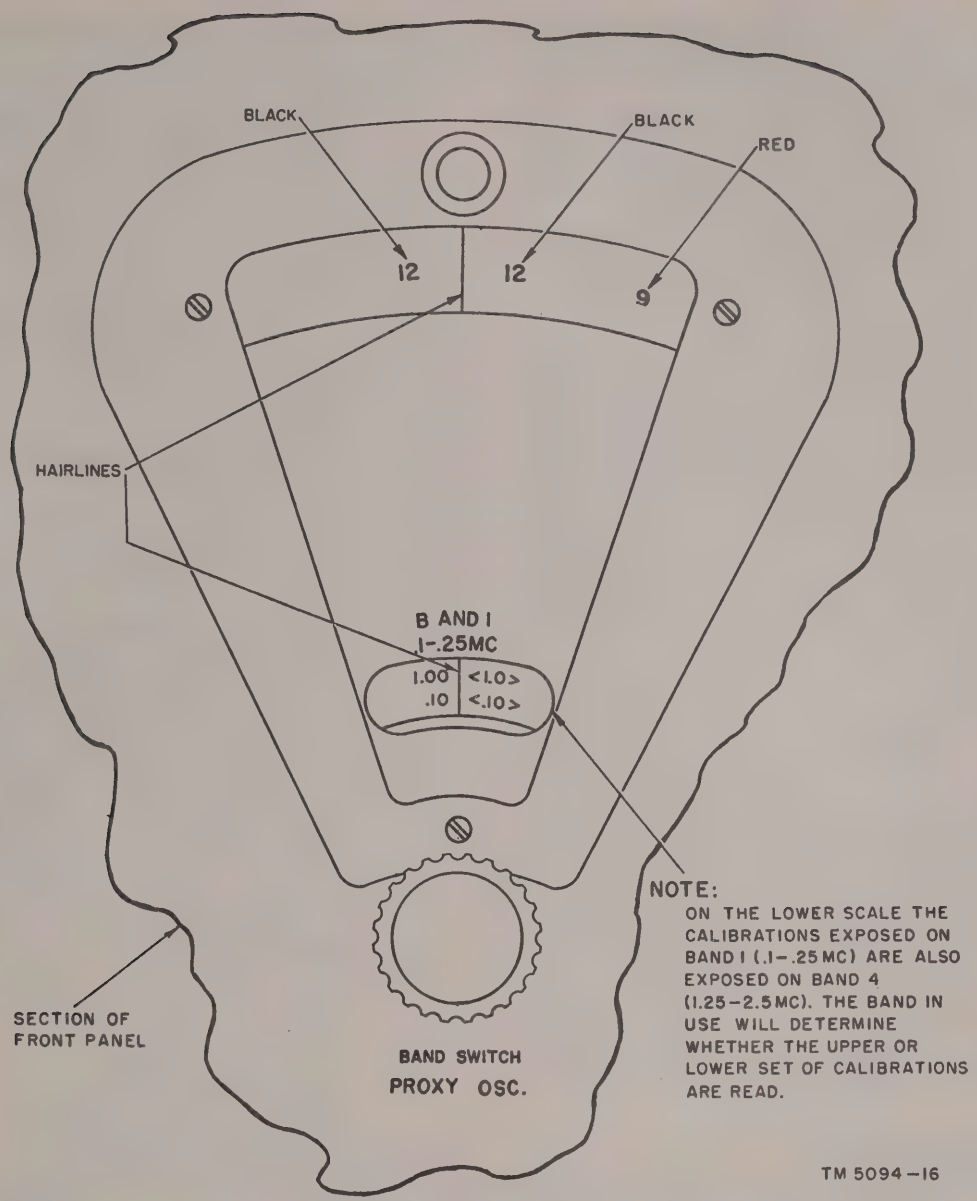

Figure 18. PROXY. OSC. dial, sample reading.

b. If the hairline falls between two dial divisions during operation, always use the *lower* division to compute the correct frequency. If the hairline falls between two harmonic numbers, select either one. Then, by following the frequency meter operational procedure described in paragraph 17*a* and *b*, adjust the INTERPOLATION OSC. dial until a single closed Lissajous pattern appears on the SCOPE. Determine whether the INTERPOLATION OSC. dial reading falls within the range of the calibration book. If it does fall within range, the choice of harmonic number was correct. If the dial reading falls outside the range of the calibration book, the other harmonic number must be used.

Note. The calibrated portion of the INTERPOLATION OSC. dial covers the range from 0 (approximately) to 5,000 dial divisions. Calibrations listed in the calibration book do not use the full range of the dial.

19. Reading INTERPOLATION OSC. Dial

a. General. The INTERPOLATION OSC. dial consists of two sections. One section is a drum-shaped dial that indicates in hundreds the reading of the dial setting. The other section is a disk-shaped dial equipped with a ver-

nier scale. The graduations on the disk are in units; tenths are provided by the vernier scale. The dial is adjusted by a knob.

Note. When turning the dial, always approach the final setting of the units dial in a clockwise direction to eliminate errors caused by blacklash in the dial gear mechanism.

b. Use of Dial. In the following example, the interpolation oscillator, during the sequence of operation, is at a setting shown in figure 19. The dial is set at 716.9. For the example given, the dial setting of 716.9 can be broken down into three parts: 700, read on hundreds dial; 16, read on units dial; .9, read on vernier scale. All markings on the hundreds dial are multiplied by 100. The markings on the unit dial are direct reading. The vernier scale is read as a decimal fraction by determining which line of the vernier scale coincides most closely with a line of the large dial.

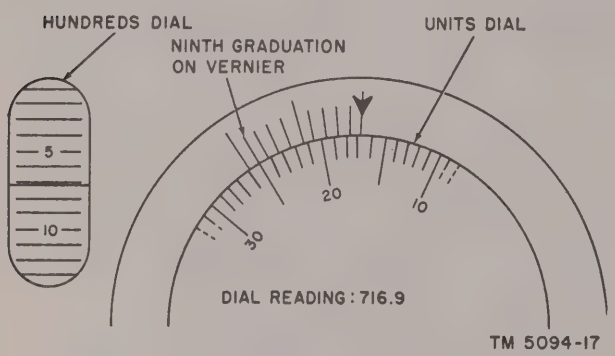

Figure 19. INTERPOLATION OSC. dial, sample reading.

20. Calibration Book

The calibration book is mounted in the drawer at the bottom of the frequency meter. To use the calibration book, pull the drawer forward and swing it downward. Each book can be used only with the interpolation oscillator subchassis the serial number of which appears on the title page. The serial number of the interpolation oscillator appears at the 50 end of the INTERPOLATION OSC. drum dial. A book with duplicate entries is stored in the transit case. Protect the spare book, since only these two books are calibrated to the interpolation oscillator installed.

a. Function. The calibration book contains the special data necessary for the interpolation procedures that should be followed in obtaining the exact value of the frequency being measured. Four basic types of information are provided by this calibration book.

(1) Interpolation frequencies in cycles that correspond to the INTERPOLATION OSC. dial settings.

(2) Crystal check point dial settings for calibrating the interpolation oscillator against a crystal-controlled harmonic of 10 kc.

(3) Lissajous pattern ratios appearing on the oscilloscope for calibrating the interpolation oscillator.

(4) Harmonic selector switch settings for calibrating the interpolation oscillator.

b. Data Location.

Note. A typical page from a calibration book shown in figure 101 is used for the following interpolation examples.

(1) CRYSTAL CHECK POINT DIAL DIV., PATTERN RATIO, and HARMONIC NUMBER appear at the bottom of each chart page and apply only to dial settings given on that page. The chart is made up of columns of interpolation frequencies in cycles that correspond to the INTERPOLATION OSC. dial settings. A total of 5,000 dial settings spaced 1 cycle apart has been determined for band 1. The band 1 numbers have been multiplied by factors of 2, 5, 10, 20, 40, and 80 for bands 2 through 7, respectively. Since these multiplication factors already have been applied, the operator uses the chart directly.

(2) Under each of *Band 1* through *Band 7* headings are two *Freq Cycles* columns. Alternate columns are printed in red and black. The proper color to use in reading the chart is obtained from the color of the number read on the PROXY. OSC. dial. The black column figures run from 0 to 5,000 cycles for corresponding dial settings ranging from 4,500 to about 188. The black column figures are *not* interpolation oscillator frequencies but are obtained by subtracting interpolation oscillator frequencies from 20,000. The red column numbers are obtained by subtracting 10,000 from the interpolation oscillator frequencies. This procedure

is required so that the calibration book may list numbers that always are added to and never subtracted from PROXY. OSC. dial readings.

c. Determination of Frequency from Given Dial Reading (Black Column). To calculate the exact frequency when the INTERPOLATION OSC. dial setting falls between two numbers in the *Dial Div* column, proceed as described below. Intermediate values are determined mathematically by interpolation. For the chosen example, an INTERPOLATION OSC. dial setting of 265.4 is obtained and the BAND switch is on BAND 7 during the sequence of operations. *The dial setting of 265.4 is an assumed value and may or may not be found in the calibration book supplied with the frequency meter. Find the dial division column values that are closest to the dial setting.* This dial setting falls between 265.1 and 265.6 in the *Dial Div* column. The two corresponding readings from the *Freq Cycles* (black) column are 377,440 and 377,360 cps, respectively. (The band and color under which these frequencies are located are determined from the harmonic scale (upper sector) of the PROXY. OSC. dial.) The actual computation is as follows:

(1) Subtract the lower dial division from the higher dial division:

$$\begin{array}{r} 265.6 \\ -265.1 \\ \hline .5 \text{ difference} \end{array}$$

(2) Subtract the lower dial division from the INTERPOLATION OSC. dial setting:

$$\begin{array}{r} 265.4 \\ -265.1 \\ \hline .3 \text{ difference} \end{array}$$

(3) Subtract the lower frequency cycles from the higher frequency cycles:

$$\begin{array}{r} 377,440 \\ -377,360 \\ \hline 80 \text{ difference} \end{array}$$

(4) Multiply the difference value 80 ((3) above) by the value .3 ((2) above):

$$\begin{array}{r} 80 \\ \times .3 \\ \hline 24.0 \end{array}$$

(5) Divide 24.0 ((4) above) by .5 ((1) above):

$$.5\overline{)24.0}\quad 48$$

(6) Subtract the quotient obtained in (5) above from the higher value frequency cycles:

$$\begin{array}{r} 792,080 \\ -\quad 48 \\ \hline 792,032 \text{ cps} \end{array}$$

This is the interpolated value of frequency cycles corresponding to the dial division of 256.5. This value then is added to the proxy oscillator frequency (par. 17).

d. Example of Interpolation Using Red Column in Calibration Book. Since the numbers in the red column of the calibration book progress oppositely from those in the black column, an additional example of interpolation, using the red column, is presented below. It is assumed that the unknown frequency is in BAND 5 and that the dial setting of the interpolation oscillator is 273.2. It is also assumed that this dial setting falls between 273.5 and 273.0 in the *Dial Div* column, which corresponds to frequencies of 105,940 and 105,920 cps, respectively. The computation is as follows:

(1) Subtract the lower dial division from the higher dial division:

$$\begin{array}{r} 273.5 \\ -273.0 \\ \hline .5 \text{ difference} \end{array}$$

(2) Subtract the lower dial division from the INTERPOLATION OSC. dial setting:

$$\begin{array}{r} 273.2 \\ -273.0 \\ \hline .2 \text{ difference} \end{array}$$

(3) Subtract the lower frequency cycles from the higher frequency cycles:

$$\begin{array}{r} 105,940 \\ -105,920 \\ \hline 20 \text{ difference} \end{array}$$

(4) Multiply the difference value 20 ((3) above) by the value .2 ((2) above):

$$\begin{array}{r} 20 \\ \times .2 \\ \hline 4.0 \end{array}$$

(5) Divide the value 4 by the value obtained in (1) above:

$$.5 \overline{)\ 4}\ \ 8 \text{ quotient}$$

(6) Add the lower value of frequency cycles to the quotient 8 ((5) above):

$$\begin{array}{r} 105920 \\ +\ \ 8 \\ \hline 105928 \text{ cps} \end{array}$$

This is the interpolated value of frequency cycles corresponding to the dial division of 273.2. This value then is added to the proxy oscillator frequency (par. 17).

e. Example of Interpolation Using Frequency Meter as Signal Generator. When using Frequency Meter FR–4/U as a signal generator, it is necessary to determine the dial division corresponding to the required output frequency (par. 17*c*). In some cases, the exact dial division setting required must be determined by interpolation, since not all possible output frequencies are listed in the calibration book. The following is a complete procedure for selecting an output frequency of 8,610,288 cps. This procedure should be used to obtain all other output frequencies that require interpolation.

(1) Turn the BAND SWITCH to the band that includes the desired frequency: in this example, BAND 6.

(2) Using the TUNING control, set the PROXY. OSC. dial as close to the desired frequency as possible.

(3) Convert the frequency appearing to the left of the hairline to cps: in this example, convert 8.4 mc to 8,400,000 cps.

(4) Subtract the frequency obtained in (3) above from the desired frequency:

$$\begin{array}{r} 8{,}610{,}288 \\ -8{,}400{,}000 \\ \hline 210{,}288 \text{ difference} \end{array}$$

(5) Extract from the calibration book under the appropriate column (in this example, *Band 6,* red) the nearest frequencies larger and smaller than the result obtained in (4) above, along with the corresponding dial division readings:

Frequency Cycles	*Dial Division*
210,320	251.6
210,280	251.1

Note. The dial division readings given above will be different for different frequency meters.

(6) Subtract the lower frequency cycles obtained in (5) above from the higher frequency cycles:

$$\begin{array}{r} 210{,}320 \\ -210{,}280 \\ \hline 40 \text{ difference} \end{array}$$

(7) Subtract the lower frequency cycles obtained in (5) above from the value obtained in (4) above:

$$\begin{array}{r} 210{,}288 \\ -210{,}280 \\ \hline 8 \text{ difference} \end{array}$$

(8) Subtract the lower dial division obtained in (5) above from the higher dial division:

$$\begin{array}{r} 251.6 \\ -251.1 \\ \hline .5 \text{ difference} \end{array}$$

(9) Multiply the value obtained in (7) above by the value obtained in (8) above:

$$\begin{array}{r} 8 \\ \times .5 \\ \hline 4 \end{array}$$

(10) Divide the value obtained in (9) above by the value obtained in (6) above:

$$40 \overline{)\ 4.0}\ \ .1$$

(11) Add the quotient obtained in (10) above to the lower dial division:

$$\begin{array}{r} 251.1 \\ +\ .1 \\ \hline 251.2 \end{array}$$

(12) Referring to data at the bottom of the calibration book page on which the proper dial division reading is located, turn the INTERPOLATION OSC. dial to the setting shown following CRYSTAL CHECK POINT DIAL DIV. (in this example, 0294.1). Set the HARMONIC NO. selector switch to the HARMONIC NUMBER shown at the bottom of the page (in this example, 23).

(13) Set FUNCTION SW. to CAL.
(14) Again referring to data on the proper calibration book page, adjust the CAL. ADJ. knob until a Lissajous figure (fig. 17) of the correct ratio appears stationary on the SCOPE. The correct ratio (in this example, 15/1) is shown following PATTERN RATIO at the bottom of the page.
(15) Set the INTERPOLATION OSC. dial to the setting obtained in (11) above (251.2).
(16) Set the HARMONIC NO. selector switch to the value shown nearest the hairline on the PROXY. OSC. dial: in this example, 20.
(17) Set the FUNCTION SW. to MEAS.
(18) Adjust the PROXY. OSC. dial slightly to obtain a stationary single loop (1 to 1 ratio) on the SCOPE.
(19) An output frequency of 8,610,290 cps ±.001 percent now will be present at SIGNAL OUTPUT jack J103.

21. Stopping Procedure

a. Snap the POWER switch to the OFF position (fig. 15).

b. Disconnect the power cable from the power outlet and stow it on the shelf below the dust cover at the rear of the frequency meter (fig. 8).

c. Disconnect the rf cable and stow it in the spares compartment of the transit case (figs. 3 and 5).

d. Close the calibration book and drawer.

e. Loosen the locking knobs and swing the tilt plates upward until detents hold them in a vertical position.

f. If Adapter UG–924/U has been used, return it to its clamp on the front panel.

Section IV. OPERATION UNDER UNUSUAL CONDITIONS

22. General

Accurate operation of Frequency Meter FR–4/U may be difficult in regions where extreme cold, heat, humidity and moisture, and/or sand conditions, etc., prevail. Although every precaution is taken in the design of the equipment to maintain its technical characteristics over a wide temperature and humidity range, adverse conditions may cause very large errors in measurements unless additional precautions are taken.

23. Operation in Arctic Climates

To protect the frequency meter from the adverse effects of subzero temperatures and climatic conditions associated with cold weather, observe the following precautions.

a. Keep the equipment warm and dry. If necessary, construct an insulated box for the frequency meter.

b. Keep the filaments of the tubes lighted constantly, unless this overtaxes the source of line power. To keep the tubes lighted, merely throw the POWER switch to ON.

c. To conserve the heat, cover the frequency meter when it is not in use with a blanket or tarpaulin.

d. If any subchassis must be removed from the frequency meter, work in a heated inclosure where there is no danger of a cold draft striking any of the temperature-sensitive parts of the equipment. If the inclosure is so constructed that such a draft is possible, place a blanket or some barrier between the source of the draft and the equipment.

e. When equipment that has been exposed to the cold is brought into a warm room, it will sweat until it reaches room temperature. When the equipment has reached room temperature, dry it thoroughly. This condition also arises when the equipment warms up during the day after exposure during a cold night.

24. Operation in Tropical Climates

When the equipment is operated in tropical climates, moisture conditions are more acute than normal; ventilation is usually very poor, and the high relative humidity causes condensation of moisture on the equipment whenever the temperature of the equipment becomes lower than the ambient air. To minimize this condition, keep the equipment in operation.

25. Operation in Desert Climates

a. The main problem that arises with equipment operation in desert areas is the large amount of sand, dust, or dirt that enters the moving parts of the equipment. The ideal preventive precaution is to house the equip-

ment in a dustproof shelter. Since such a building is seldom available and would require air conditioning, the next best precaution is to make the building in which the equipment is located as dustproof as possible with available materials. Hang wet sacking over the windows and doors, cover the inside walls with heavy paper, and secure the side walls of tents with sand to prevent their flapping in the wind.

b. Never tie power cords, signal cords, or other wiring connections to tent walls. Buffeting of the tent walls may damage the connections or break the lines.

c. Be sure to keep the equipment as free of dust as possible. Make frequent preventive maintenance checks; pay particular attention to the cleanliness of the two gear trains and the gang capacitor.

d. A drastic fall in temperature at night often causes condensation. To minimize the effect of condensation, cover the equipment with tarpaulin or a similar covering material.

CHAPTER 3
ORGANIZATIONAL MAINTENANCE

Section I. ORGANIZATIONAL TOOLS AND EQUIPMENT

26. General

a. Usually, a number of tools, materials, or tool equipment kits are either furnished with the equipment or supplied to the organization for use with equipment.

b. The actual allowable organizational maintenance that can be performed on Frequency Meters AN/URM–79 and AN/URM–81 depends to a large extent on the existing military regulations (Standing Operating Procedure), the existing tactical situation, and on the tools and other test equipment issued.

27. Tools and Materials

a. Five Allen wrenches are supplied with the equipment. They are mounted on the shelf containing the calibration book.

b. Tools and materials used, but not supplied, with the frequency meter are listed in (1) and (2) below. The tools and materials contained in Tool Equipment TE–41 are listed in Department of the Army Supply Manual SIG 6–TE–41.

(1) *Tools.*

1 Tool Equipment TE–41

(2) *Materials.*

Orangestick, Stock No. 6Z7360.
Cheesecloth, Stock No. 6Z1989.
Carbon tetrachloride, Chemical Corps No. 122584.
Solvent, Dry Cleaning (SD) (Fed P–S–661a).

Section II. PREVENTIVE MAINTENANCE SERVICES

28. Definition of Preventive Maintenance

Preventive maintenance is work performed on equipment (usually when the equipment is not in use) to maintain it in good working order so that breakdowns and needless interruptions in service will be kept to a minimum. Preventive maintenance differs from troubleshooting and repair since its object is to prevent certain troubles from occurring.

29. General Preventive Maintenance Techniques

a. Use No. 000 sandpaper to remove corrosion.

b. Use a clean, dry, lint-free cloth or a dry brush for cleaning.

(1) When cleaning surfaces that have no electrical function, use a cloth or brush moistened with solvent (SD). After cleaning, wipe the parts dry with a cloth.

(2) Clean electrical contacts with a cloth moistened with carbon tetrachloride. Then wipe them dry with a dry cloth.

Caution: Repeated contact of carbon tetrachloride with the skin or prolonged breathing of the fumes is dangerous. Make sure adequate ventilation is provided.

c. If available, dry compressed air may be used at a line pressure not exceeding 60 pounds per square inch to remove dust from inaccessible places. Be careful not to cause mechanical damage with the air blast.

d. For further information on preventive maintenance techniques, refer to TB SIG 178, Preventive Maintenance Guide for Radio Communication Equipment.

30. Use of Preventive Maintenance Forms (figs. 20 and 21)

a. The application of items on DA Forms 11–238 and 11–239 to this equipment is a tactical decision to be made in the case of first echelon maintenance by the communication officer/chief or his designated representative,

OPERATOR FIRST ECHELON MAINTENANCE CHECK LIST FOR SIGNAL CORPS EQUIPMENT
RADIO COMMUNICATION, DIRECTION FINDING, CARRIER, RADAR

INSTRUCTIONS: See other side

EQUIPMENT NOMENCLATURE	EQUIPMENT SERIAL NO.

LEGEND FOR MARKING CONDITIONS: ✓ Satisfactory; X Adjustment, repair or replacement required; (X) Defect corrected.
NOTE: Strike out items not applicable.

DAILY

NO.	ITEM	CONDITION S	M	T	W	T	F	S
(1)	COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT *(receiver, transmitter, carrying cases, wire and cable, microphones, tubes, spare parts, technical manuals and accessories).* PAR. 31a							
2	LOCATION AND INSTALLATION SUITABLE FOR NORMAL OPERATION.							
(3)	CLEAN DIRT AND MOISTURE FROM ANTENNA, MICROPHONE, HEADSETS, CHESTSETS, KEYS, JACKS, PLUGS, TELEPHONES, CARRYING BAGS, COMPONENT PANELS. PAR. 31b							
(4)	INSPECT SEATING OF READILY ACCESSIBLE "PLUCK-OUT" ITEMS: TUBES, LAMPS, CRYSTALS, FUSES, CONNECTORS, VIBRATORS, PLUG-IN COILS AND RESISTORS. PAR. 31c							
(5)	INSPECT CONTROLS FOR BINDING, SCRAPING, EXCESSIVE LOOSENESS, WORN OR CHIPPED GEARS, MISALIGNMENT, POSITIVE ACTION. PAR. 31d							
(6)	CHECK FOR NORMAL OPERATION. PAR. 31e							

WEEKLY

NO.	ITEM	CONDITION	NO.	ITEM	CONDITION
(7)	CLEAN AND TIGHTEN EXTERIOR OF COMPONENTS AND CASES, RACK MOUNTS, SHOCK MOUNTS, ANTENNA MOUNTS, COAXIAL TRANSMISSION LINES, WAVE GUIDES, AND CABLE CONNECTIONS. PAR. 31f		13	INSPECT STORAGE BATTERIES FOR DIRT, LOOSE TERMINALS, ELECTROLYTE LEVEL AND SPECIFIC GRAVITY, AND DAMAGED CASES.	
(8)	INSPECT CASES, MOUNTINGS, ANTENNAS, TOWERS, AND EXPOSED METAL SURFACES, FOR RUST, CORROSION, AND MOISTURE. PAR. 31g		14	CLEAN AIR FILTERS, BRASS NAME PLATES, DIAL AND METER WINDOWS, JEWEL ASSEMBLIES.	
(9)	INSPECT CORD, CABLE, WIRE, AND SHOCK MOUNTS FOR CUTS, BREAKS, FRAYING, DETERIORATION, KINKS, AND STRAINS. PAR. 31h		(15)	INSPECT METERS FOR DAMAGED GLASS AND CASES. PAR. 31j	
10	INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED INSULATORS AND REFLECTORS.		16	INSPECT SHELTERS AND COVERS FOR ADEQUACY OF WEATHERPROOFING.	
11	INSPECT CANVAS ITEMS, LEATHER, AND CABLING FOR MILDEW, TEARS, AND FRAYING.		17	CHECK ANTENNA GUY WIRES FOR LOOSENESS AND PROPER TENSION.	
(12)	INSPECT FOR LOOSENESS OF ACCESSIBLE ITEMS: SWITCHES, KNOBS, JACKS, CONNECTORS, ELECTRICAL TRANSFORMERS, POWERSTATS, RELAYS, SELSYNS, MOTORS, BLOWERS, CAPACITORS, GENERATORS, AND PILOT LIGHT ASSEMBLIES. PAR. 31i		18	CHECK TERMINAL BOX COVERS FOR CRACKS, LEAKS, DAMAGED GASKETS, DIRT AND GREASE.	

19 IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.

DA FORM 1 MAY 51 11-238 REPLACES DA AGO FORM 419, 1 DEC 50, WHICH IS OBSOLETE.

TM 5094-18

Figure 20. DA Form 11-238.

SECOND AND THIRD ECHELON MAINTENANCE CHECK LIST FOR SIGNAL CORPS EQUIPMENT
RADIO COMMUNICATION, DIRECTION FINDING, CARRIER, RADAR

INSTRUCTIONS: See other side

EQUIPMENT NOMENCLATURE | EQUIPMENT SERIAL NO.

LEGEND FOR MARKING CONDITIONS: ✓ Satisfactory; X Adjustment, repair or replacement required; ① Defect corrected.
NOTE: Strike out items not applicable.

NO.	ITEM	CONDITION
1	COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT *(receiver, transmitter, carrying cases, wire and cable, microphones, tubes, spare parts, technical manuals and accessories).* PAR.31a	
2	LOCATION AND INSTALLATION SUITABLE FOR NORMAL OPERATION.	
3	CLEAN DIRT AND MOISTURE FROM ANTENNA, MICROPHONE, HEADSETS, CHESTSETS, KEYS, JACKS, PLUGS, TELEPHONES, CARRYING BAGS, COMPONENT PANELS. PAR.31b	
4	INSPECT SEATING OF READILY ACCESSIBLE "PLUCK-OUT" ITEMS: TUBES, LAMPS, CRYSTALS, FUSES, CONNECTORS, VIBRATORS, PLUG-IN COILS AND RESISTORS. PAR.31c	
5	INSPECT CONTROLS FOR BINDING, SCRAPING, EXCESSIVE LOOSENESS, WORN OR CHIPPED GEARS, MISALIGNMENT, POSITIVE ACTION. PAR.31d	
6	CHECK FOR NORMAL OPERATION. PAR.31e	
7	CLEAN AND TIGHTEN EXTERIOR OF COMPONENTS AND CASES, RACK MOUNTS, SHOCK MOUNTS, ANTENNA MOUNTS, COAXIAL TRANSMISSION LINES, WAVE GUIDES, AND CABLE CONNECTIONS. PAR.31f	
8	INSPECT CASES, MOUNTINGS, ANTENNAS, TOWERS, AND EXPOSED METAL SURFACES, FOR RUST, CORROSION, AND MOISTURE. PAR.31g	
9	INSPECT CORD, CABLE, WIRE, AND SHOCK MOUNTS FOR CUTS, BREAKS, FRAYING, DETERIORATION, KINKS, AND STRAIN. PAR.31h	
10	INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED INSULATORS AND REFLECTORS.	
11	INSPECT CANVAS ITEMS, LEATHER, AND CABLING FOR MILDEW, TEARS, AND FRAYING.	
12	INSPECT FOR LOOSENESS OF ACCESSIBLE ITEMS: SWITCHES, KNOBS, JACKS, CONNECTORS, ELECTRICAL TRANSFORMERS, POWERSTATS, RELAYS, SELSYNS, MOTORS, BLOWERS, CAPACITORS, GENERATORS, AND PILOT LIGHT ASSEMBLIES. PAR.31i	
13	INSPECT STORAGE BATTERIES FOR DIRT, LOOSE TERMINALS, ELECTROLYTE LEVEL AND SPECIFIC GRAVITY, AND DAMAGED CASES.	
14	CLEAN AIR FILTERS, BRASS NAME PLATES, DIAL AND METER WINDOWS, JEWEL ASSEMBLIES.	
15	INSPECT METERS FOR DAMAGED GLASS AND CASES. PAR.31j	
16	INSPECT SHELTERS AND COVERS FOR ADEQUACY OF WEATHERPROOFING.	
17	CHECK ANTENNA GUY WIRES FOR LOOSENESS AND PROPER TENSION.	
18	CHECK TERMINAL BOX COVERS FOR CRACKS, LEAKS, DAMAGED GASKETS, DIRT AND GREASE.	
19	ELECTRON TUBES - INSPECT FOR LOOSE ENVELOPES, CAP CONNECTORS, CRACKED SOCKETS; INSUFFICIENT SOCKET SPRING TENSION; CLEAN DUST AND DIRT CAREFULLY; CHECK EMISSION OF RECEIVER TYPE TUBES. PAR. 32b	
20	INSPECT FILM CUT-OUTS FOR LOOSE PARTS, DIRT, MISALIGNMENT AND CORROSION.	
21	INSPECT FIXED CAPACITORS FOR LEAKS, BULGES, AND DISCOLORATION.	
22	INSPECT RELAY AND CIRCUIT BREAKER ASSEMBLIES FOR LOOSE MOUNTINGS; BURNED, PITTED, CORRODED CONTACTS; MISALIGNMENT OF CONTACTS AND SPRINGS; INSUFFICIENT SPRING TENSION; BINDING OF PLUNGERS AND HINGE PARTS.	
23	INSPECT VARIABLE CAPACITORS FOR DIRT, MOISTURE, MISALIGNMENT OF PLATES, AND LOOSE MOUNTINGS. PAR. 32c	
24	INSPECT RESISTORS, BUSHINGS, AND INSULATORS, FOR CRACKS, CHIPPING, BLISTERING, DISCOLORATION AND MOISTURE. PAR.32d	
25	INSPECT TERMINALS OF LARGE FIXED CAPACITORS AND RESISTORS FOR CORROSION, DIRT AND LOOSE CONTACTS.	
26	CLEAN AND TIGHTEN SWITCHES, TERMINAL BLOCKS, BLOWERS, RELAY CASES, AND INTERIORS OF CHASSIS AND CABINETS NOT READILY ACCESSIBLE. PAR.32e	
27	INSPECT TERMINAL BLOCKS FOR LOOSE CONNECTIONS, CRACKS AND BREAKS. PAR.32f	
28	CHECK SETTINGS OF ADJUSTABLE RELAYS.	
29	LUBRICATE EQUIPMENT IN ACCORDANCE WITH APPLICABLE DEPARTMENT OF THE ARMY LUBRICATION ORDER.	
30	INSPECT GENERATORS, AMPLIDYNES, DYNAMOTORS, FOR BRUSH WEAR, SPRING TENSION, ARCING, AND FITTING OF COMMUTATOR.	
31	CLEAN AND TIGHTEN CONNECTIONS AND MOUNTINGS FOR TRANSFORMERS CHOKES, POTENTIOMETERS, AND RHEOSTATS. PAR. 32g	
32	INSPECT TRANSFORMERS, CHOKES, POTENTIOMETERS, AND RHEOSTATS FOR OVERHEATING AND OIL-LEAKAGE. PAR. 32h	
33	BEFORE SHIPPING OR STORING - REMOVE BATTERIES.	
34	INSPECT CATHODE RAY TUBES FOR BURNT SCREEN SPOTS. PAR. 32i	
35	INSPECT BATTERIES FOR SHORTS AND DEAD CELLS.	
36	INSPECT FOR LEAKING WATERPROOF GASKETS, WORN OR LOOSE PARTS.	
37	MOISTURE AND FUNGIPROOF. PAR. 32j	
38	IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.	

DA FORM 1 MAY 51 11-239 REPLACES DA AGO FORM 419, 1 DEC 50, WHICH IS OBSOLETE.

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Figure 21. DA Form 11-239.

and, in the case of second and third echelon maintenance, by the inspecting personnel. Instructions for the use of each form appear on its reverse side.

b. Circled items on figures 20 and 21 are partially or totally applicable to the frequency meter. References in the ITEM column are to paragraphs in the text that contain the required detailed, or additional maintenance, information.

31. Performing Exterior Preventive Maintenance

Caution: Tighten screws, bolts, and nuts carefully. Fittings tightened beyond the pressure for which they are designed will be damaged or broken.

a. Check for completeness and general condition of the frequency meter. The components of the equipment are listed in paragraph 6.

b. Clean dust and moisture from the transit case, front panel, and connectors.

c. Inspect seating of fuses F601 and F602 and BLINKER neon light I 501.

d. Inspect controls for binding, scraping, excessive looseness, and for positive action.

e. Check the equipment for normal operation. This can be done by measuring the frequency of some standard, following the operating procedure of paragraph 17*a*.

f. Clean and tighten the exterior of meter cabinet.

g. Inspect exposed surfaces of the meter case and the dust cover for rust and corrosion.

h. Inspect the power and rf cables for breaks, deterioration, and loose connectors.

i. Inspect for looseness of accessible items, such as the dials, control knobs, and jacks.

j. Inspect TUNING METER M501 for damaged glass or case.

k. Inspect the SCOPE for damage to covering glass.

32. Performing Interior Preventive Maintenance

Caution: Disconnect all power from the equipment before performing the following operations. Upon completion, reconnect power and check for satisfactory operation of the equipment.

a. Remove the dust cover, and disconnect all the subchassis from the junction box. Remove the screws holding each subchassis to the main frame. Remove the control knobs and slide the subchassis free of the frame. The subchassis may be reconnected to the junction box for servicing.

b. Inspect tubes for loose envelopes.

c. Inspect variable capacitors for dirt and loose mounting lugs. Also check the capacitors for misalinement of the plates in the stator and rotor.

Caution: Do not bend the plates of the variable capacitors while examining them.

d. Inspect resistors, bushings, and insulators, for cracks, chipping, blistering, discoloration, and moisture.

e. Clean and tighten switches, terminal blocks, and the interiors of chassis not readily accessible.

f. Inspect terminal boards for loose connections, cracks, and breaks.

g. Clean and tighten the connections and the mountings for transformers, chokes, and potentiometers.

h. Inspect transformers, chokes, and potentiometers for overheating.

i. Inspect cathode-ray tube V505 for burned screen spots.

j. Check moistureproof and fungiproof varnish for cracks and chipping.

Section III. LUBRICATION AND WEATHERPROOFING

33. Lubrication

No lubrication is required.

34. Weatherproofing Procedures and Precautions

a. General. Signal Corps equipment, when operated under severe climatic conditions such as those prevailing in tropical, arctic, and desert regions, requires special treatment and maintenance. Fungus growth, insects, dust, corrosion, salt spray, excessive moisture, and extreme temperatures are harmful to most materials.

b. Tropical Maintenance. A special moistureproofing and fungiproofing treatment has been devised which, if properly applied, provides a reasonable degree of protection. This treatment is explained in TB SIG 13, Moisture-

proofing and Fungiproofing Signal Corps Equipment, and TB SIG 72, Tropical Maintenance of Ground Signal Equipment. The equipment is given the moistureproofing and fungiproofing treatment at the factory and it is necessary to use this treatment only when parts are replaced or repaired.

c. Arctic Maintenance. Special precautions necessary to prevent poor performance or total operational failure of equipment in extremely low temperatures are explained in TB SIG 66, Winter Maintenance of Signal Equipment, and TB SIG 219, Operation of Signal Equipment at Low Temperatures.

d. Desert Maintenance. Special precautions necessary to prevent equipment failure in areas subject to extremely high temperatures, low humidity, and excessive sand and dust are explained in TB SIG 75, Desert Maintenance of Ground Signal Equipment.

35. Rustproofing and Painting

a. When the finish on the case has been badly scarred or damaged, rust and corrosion can be prevented by touching up bared surfaces. Use No. 000 sandpaper to clean the surface down to the bare metal; obtain a bright, smooth finish.

Caution: Do not use steel wool. Minute particles frequently enter the case and cause internal shorting or grounding of circuits.

b. When a touchup job is necessary, apply paint with a small brush. Remove rust from the case by cleaning corroded metal with solvent (SD). In severe cases, it may be necessary to use solvent (SD) to soften the rust and to use sandpaper to complete the preparation for painting. Paint used will be authorized and consistent with existing regulations.

Section IV. TROUBLESHOOTING AT ORGANIZATIONAL MAINTENANCE LEVEL

36. General

a. The troubleshooting and repair work that can be performed at the organizational maintenance level (operators and repairmen) is necessarily limited in scope by the tools, test equipment, and replaceable parts issued, and by the existing tactical situation. Accordingly, troubleshooting is based on the performance of the equipment and the use of the senses in determining such troubles as burned-out fuses, broken cords, defective tubes, or cracked insulators.

b. The paragraphs that follow help to determine which of the circuits is at fault and in localizing the fault in the circuit to the defective stage or item, such as a tube or fuse.

37. Visual Inspection

a. Failure of this equipment to operate properly usually will be caused by one or more of the following faults:

(1) Worn, broken, or disconnected cords or connectors.
(2) Burned-out fuses.
(3) Defective tubes.
(4) Inactive or defective crystal.

b. When failure is encountered and the cause is not immediately apparent, check as many of these items as is practicable before starting a detailed examination of the component parts of the system. If possible, obtain information from the operator of the equipment regarding performance at the time trouble occurred.

38. Troubleshooting by Using Equipment Performance Checklist

a. General. The equipment performance checklist (par. 39) will help the operator locate trouble in the equipment. The list gives the item to be checked, the conditions under which the item is checked, the normal indications and tolerances of correct operation, and the corrective measures that the operator can take. To use this list, follow the items in numerical sequence.

b. Action or Condition. For some items, the information given in the *action or condition* column consists of various switch and control settings under which the item is to be checked. For other items, it represents an action that must be taken to check the normal indication given in the *normal indications* column.

c. Normal Indications. The normal indications listed include the visible and audible signs that the operator should perceive when he checks the items. If the indications are not normal, the operator should apply the recommended corrective measures.

d. Corrective Measures. The corrective measures are those the operator can make without turning in the equipment for repairs. A reference to paragraph 77 indicates that the trouble cannot be corrected during operation and that troubleshooting by an experienced repairman is necessary. If the set is completely inoperative, or if the recommended corrective measures do not yield results, troubleshooting is necessary. However, if the tactical situation requires that the equipment be maintained and if the set is not completely inoperative, the operator must keep the set operating as long as possible.

39. Equipment Performance Checklist

The equipment performance checklist is based on the operation of the equipment as a frequency meter.

	Item No.	Item	Action or condition	Normal indications	Corrective measures
PREPARATORY	1	Switch S602 (in power supply subchassis).	Setting of switch should correspond to line voltage.		Unscrew switch lock and set switch in proper position. Tighten switch lock.
	2	Rf cable	Connect to SIGNAL INPUT jacks and source of unknown frequency.		
	3	INPUT ATTENUATOR (R144).	Set to midposition.		
	4	Earphones	Connect to PHONES jack.		
START	5	POWER switch (S601)	Turn to ON	PROXY OSC. dial lamp (I 101) lights.	Check fuses F601 and F602. Check line cord and plug.
				OVEN HEATER lamp lights and cycles dimly.	Replace dial lamp or OVEN HEATER lamp I 201. Refer to paragraph 77.
				Trace appears on SCOPE.	Refer to paragraph 77.
				Low-level hum on earphones.	Refer to paragraph 77.
EQUIPMENT PERFORMANCE	6	METER ZERO control (R539).	If needed, adjust to zero TUNING METER.	Meter reads zero with no input.	Refer to paragraph 77.
	7	BAND SWITCH (S101).	Set to desired band.		
	8	TUNING control	Adjust for maximum swing on TUNING METER.	Needle of TUNING METER moves from zero setting.	If meter overloads, adjust INPUT ATTENUATOR until needle falls within green band on meter.
			Adjust for zero beat.	Zero beat indicated on earphones and BLINKER.	Refer to paragraph 77.
			Set hairline directly over harmonic number on PROXY. OSC. dial.		
	9	HARMONIC NO. selector switch (S303).	Set to harmonic number indicated on PROXY. OSC. dial.		
	10	FUNCTION SW.	Set to MEAS. position.		
	11	INTERPOLATION OSC. dial.	Adjust for appearance of proper Lissajous pattern on SCOPE.	Single, closed pattern.	Refer to paragraph 77.
	12	HOR. GAIN control (R536).	Adjust setting of control.	Width of scope pattern approximately 1 inch.	Refer to paragraph 77.
	13	CAL. ADJ. (C402)	In calibration procedure, adjust for correct Lissajous pattern ratio.	Correct pattern ratio as given in calibration book appears on SCOPE.	Refer to paragraph 77.
STOP	14	POWER switch	Turn to OFF	PROXY. OSC. dial light goes out. TUNING METER reads zero.	

CHAPTER 4
THEORY

40. Block Diagrams

Four block diagrams are used in discussing the basic functioning of Frequency Meter FR–4/U. Refer to the overall schematic diagram (fig. 100) for more detailed overall circuit information.

a. Simplified Block Diagram, Band 1, Direct Measure (fig. 22). In Frequency Meter FR–4/U, it is possible to measure frequencies in band 1 (100 to 250 kc) by either a direct method (FUNCTION SW. in DIRECT MEAS. BAND 1 position) or an indirect method involving the proxy oscillator (FUNCTION SW. in MEAS. position). Since the method of direct measurement illustrates the basic operation of the frequency meter in the simplest manner, this method will be discussed first. The operation of the frequency meter on band 1, direct measure (100 to 250 kc) is shown in simplified form in figure 22. When the FUNCTION SW. is placed in the DIRECT MEAS. BAND 1 position, the unknown signal and the output of the harmonic selector are both fed into the measure mixer. The harmonic selector has a crystal-controlled output consisting of harmonics (9th to 26th) of 10 kc. In operation, the correct harmonic of 10 kc is selected. This harmonic will produce a difference frequency in the range of 15 to 20 kc when it is heterodyned with the unknown signal in the measure mixer. The difference frequency, after passing through a 15- to 20-kc band-pass filter, is compared by means of an oscilloscope with the frequency generated by an interpolation oscillator. When a single, closed Lissajous pattern is obtained on the oscilloscope, the interpolation oscillator frequency is the same as the difference frequency. The INTERPOLATION OSC. dial then is read and interpreted by means of the calibration book. The number given in the calibration book is added to the frequency indicated at the left of the hairline on the PROXY. OSC. dial. The sum of these two numbers is the unknown frequency measured to an accuracy of .001 percent.

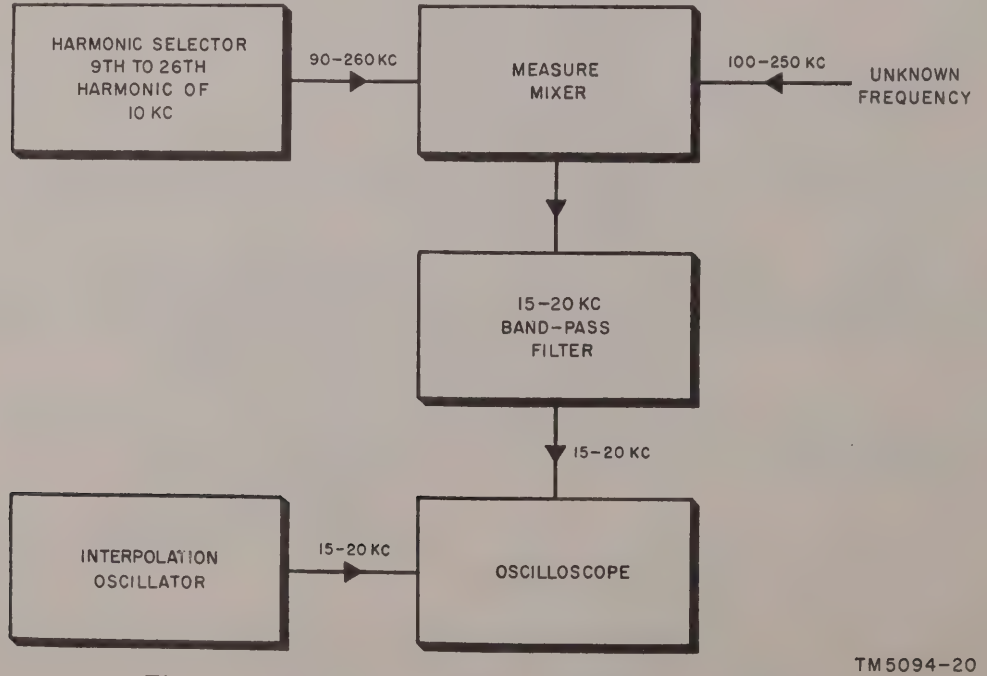

Figure 22. Band 1, direct measure, simplified block diagram.

b. Simplified Block Diagram, Bands 1 through 7, Indirect Measure (fig. 23). To extend the range of the frequency meter, a proxy oscillator, frequency multipliers, and a zero mixer have been included. A simplified block diagram showing operation by indirect measurement on bands 1 through 7 (100 kc to 20 mc) is given in figure 23. On these bands, the output of the proxy oscillator (100 to 250 kc), or a multiple thereof, is substituted for the unknown signal in the measure mixer. On band 1, the proxy oscillator is adjusted to the unknown frequency. On bands 2 through 7, the proxy oscillator is adjusted to the appropriate submultiple of the unknown frequency. The correct submultiple of the unknown frequency is multiplied by factors of 2, 5, 10, 20, 40, and 80 on bands 2 through 7. The original or multiplied proxy oscillator frequency is zero beat with the unknown frequency in the zero mixer. When zero beat is obtained, the proxy oscillator is operating at the unknown frequency (band 1), or at an exact submultiple of the unknown frequency (bands 2 through 7). The output of the proxy oscillator then is substituted for the unknown frequency and is used for measuring the unknown frequency in the same manner the unknown signal was used on band 1 (DIRECT MEAS. BAND 1). The PROXY. OSC. dial is calibrated directly in terms of the unknown frequency rather than the proxy oscillator frequency on bands 2 through 7, so there will be direct reading on these bands.

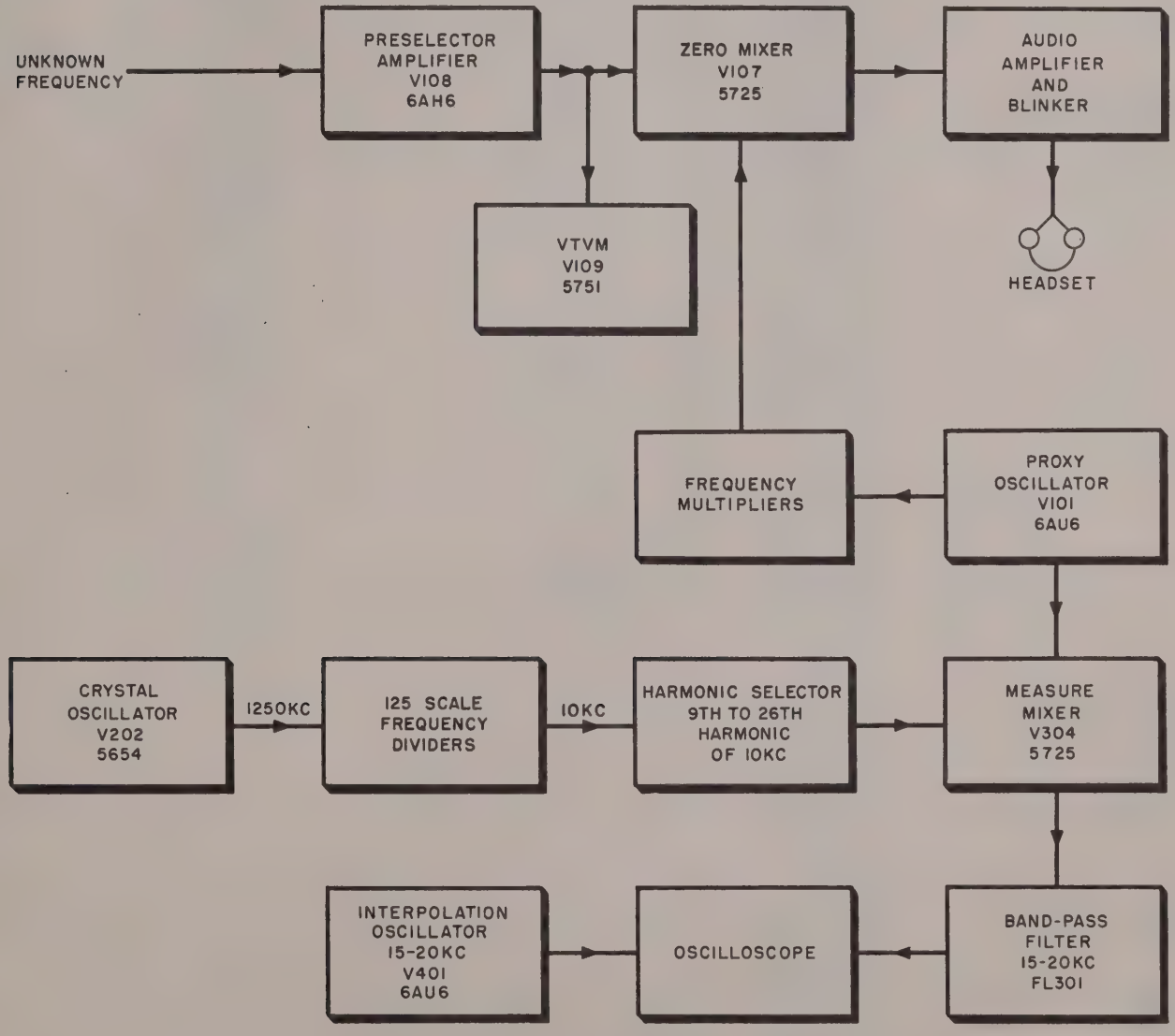

Figure 23. Indirect measure, simplified block diagram.

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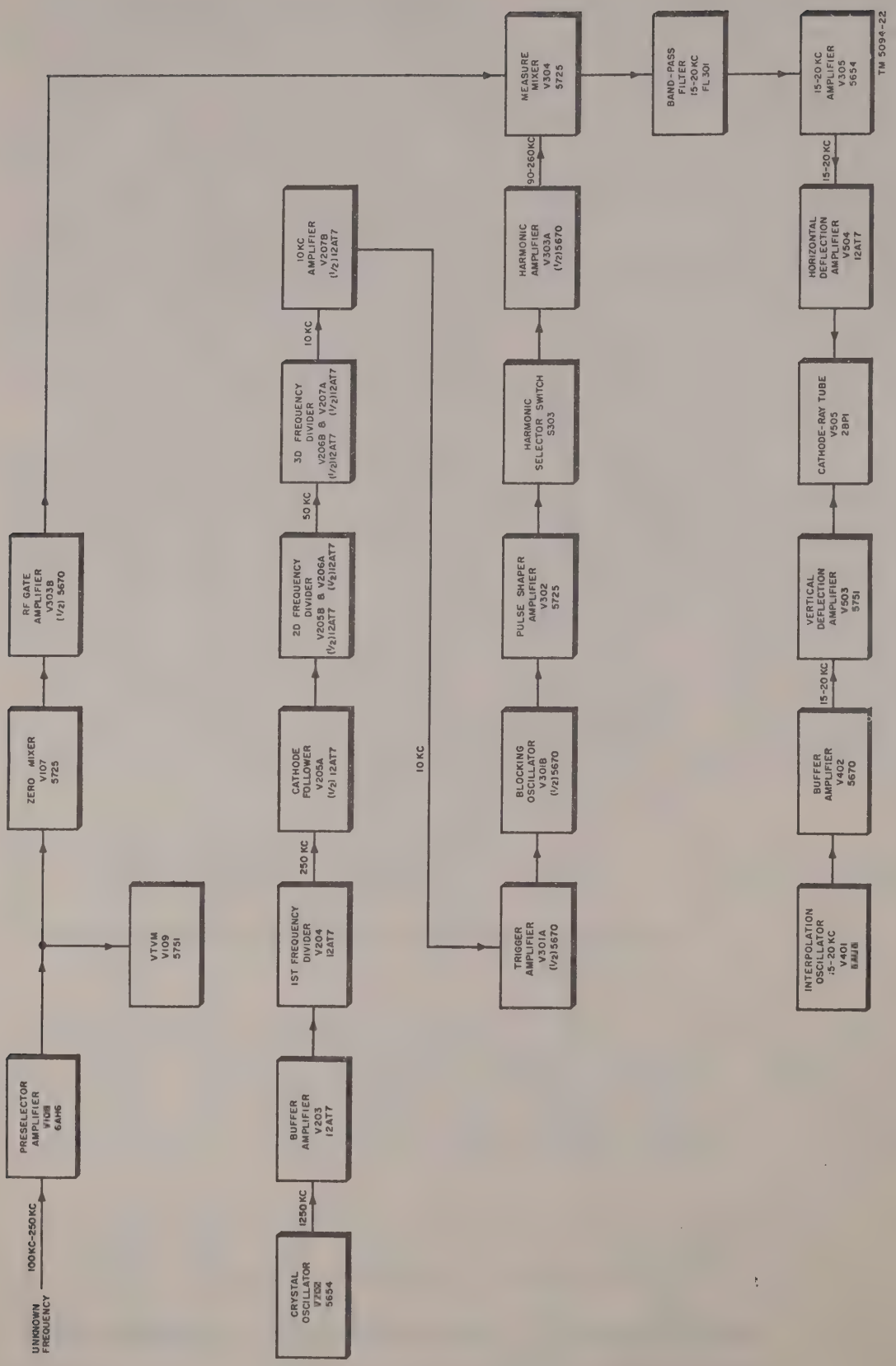


Figure 24. Band 1, direct measure, complete block diagram.

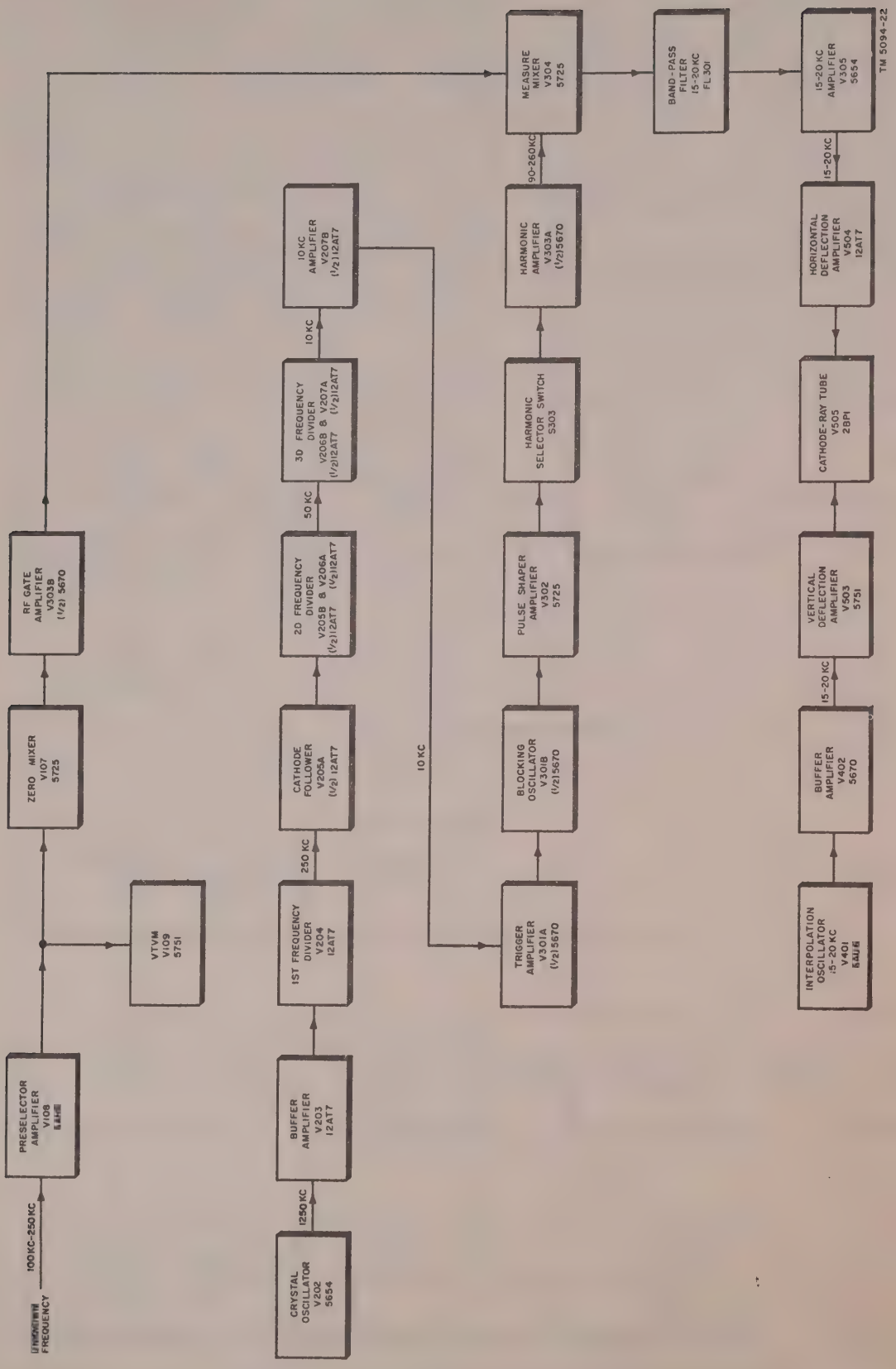


Figure 24. Band 1, direct measure, complete block diagram.

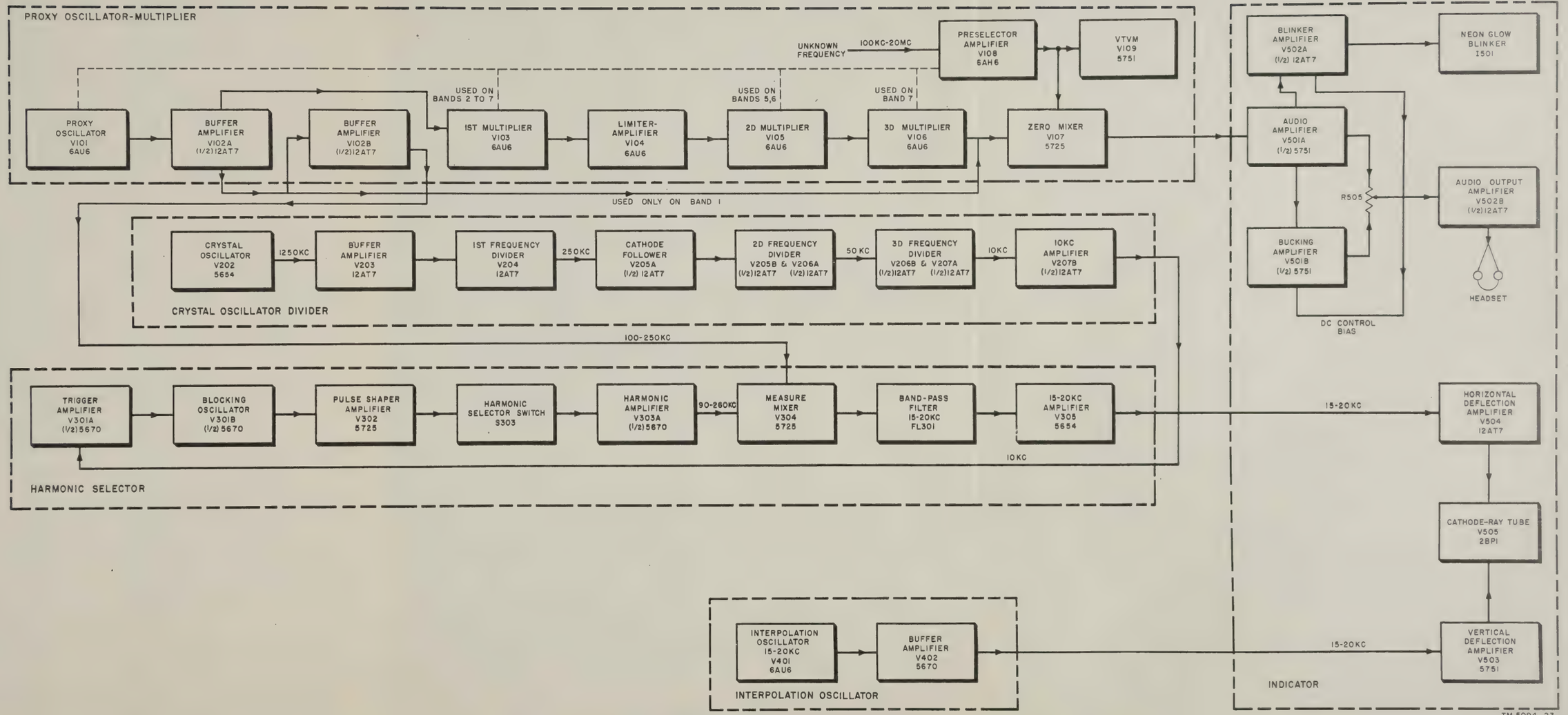


Figure 25. Indirect measure, complete block diagram.

c. Complete Block Diagram, Band 1, Direct Measure. A detailed block diagram showing the operation of Frequency Meter FR–4/U with the FUNCTION SW. in the DIRECT MEAS. BAND 1 position, appears in figure 24.

(1) *Preselector amplifier.* Preselector amplifier V108 uses a 6AH6 pentode. The unknown frequency is applied to this stage. The preselector amplifier has an input frequency range of 100 kc to 20 mc, covered in seven bands. The desired band is selected by the BAND SWITCH on front panel. This stage amplifies the input signal and feeds it to vacuum-tube voltmeter (vtvm) V109 and to zero mixer V107.

(2) *Vacuum-tube voltmeter.* One output of the preselector amplifier is applied to vtvm V109. V109 is a dual triode, type 5751, that acts as a rectifier for the rf signal and a direct-current (dc) amplifier for the rectified signal. The output of this stage is fed to a meter (TUNING METER) located on the indicator subchassis which is used for preliminary tuning of the preselector amplifier to an unknown signal.

(3) *Zero mixer.* The unknown signal output from the preselector amplifier also is fed to zero mixer V107, a type 5725 tube. With the FUNCTION SW. in DIRECT MEAS. BAND 1 position, V107 has no mixing function but it acts as a straight amplifier. The output of the zero mixer is sent to rf gate amplifier V303B.

(4) *Rf gate amplifier.* The rf gate amplifier, V303B, is energized only on DIRECT MEAS. BAND 1 by means of contacts on the BAND SWITCH. The amplifier uses one-half of a type 5670 dual triode. This stage functions as a straight amplifier on DIRECT MEAS. BAND 1 (100 to 250 kc). The output of this stage is fed to measure mixer V304.

(5) *Measure mixer.* Measure mixer V304 uses a type 5725 tube. Two signals are applied to this stage. One input comes from the rf gate amplifier on DIRECT MEAS. BAND 1, or from the proxy oscillator buffer on bands 1 through 7 when FUNCTION SW. is in MEAS. position. The other input is applied from harmonic amplifier V303A. This later input is a crystal-controlled harmonic of 10 kc ranging from the 9th to the 26th (90 to 260 kc). For any given unknown frequency the proper 10-kc harmonic is chosen which, when heterodyned with the unknown frequency in the measure mixer, will produce a difference frequency in the range of 15 to 20 kc. The output of the measure mixer is applied to the 15- to 20-kc band-pass filter.

(6) *15- to 20-kc amplifier.* A type 5654 pentode tube is used for the 15- to 20-kc amplifier, V305. This stage serves as a termination for the 15- to 20-kc band-pass filter and amplifies the 15- to 20-kc signals applied to it from the filter. When FUNCTION SW. S301 is in DIRECT MEAS. BAND 1 or MEAS. position, the output of V305 is fed to the horizontal deflection amplifier on the indicator subchassis.

(7) *Band-pass filter.* The band-pass filter is a highly selective filter that passes only the band of frequencies between 15 and 20 kc.

(8) *Crystal oscillator.* Crystal oscillator V202 operates at a frequency of 1,250 kc. The crystal is contained in a temperature-stabilized oven to insure maximum frequency stability. A trimmer capacitor is provided to calibrate the crystal oscillator against a frequency standard. A type 5654 pentode tube is used and the 1,250-kc output goes to the buffer amplifier. The 1,250-kc output of the crystal oscillator is not used directly, but it is divided to 10 kc by three frequency dividers.

(9) *Buffer amplifier.* Buffer amplifier V203 is a dual triode, type 12AT7. The first section is a cathode follower and the second, a grounded-grid amplifier. The function of the buffer amplifier is to isolate the crystal oscillator from load changes, thus improv-

ing stage stability. The output is taken from the second section of the buffer and is applied to first frequency divider V204.

(10) *First frequency divider.* The first frequency divider, V204, is a regenerative-type divider using a 12AT7 dual triode tube. The stage divides the input frequency of 1,250 kc by a factor of five and produces an output of 250 kc. Frequency control is accomplished by means of tank circuits tuned to 1,000 kc and 250 kc. The 250-kc output of the first frequency divider is fed to cathode follower V205A.

(11) *Cathode follower.* Cathode follower V205A is a conventional circuit that used one-half of a 12AT7 dual triode. It isolates the first and second frequency dividers to provide improved stability. The 250-kc output of the cathode follower is fed to second frequency divider V205B and V206A.

(12) *Second frequency divider.* The second frequency divider also divides by a factor of five. It is similar in circuitry to the first frequency divider. V205B and V206A, two triode sections of separate 12AT7 tubes, are used. The input frequency is 250 kc and the output frequency is 50 kc, the latter being fed to third frequency divider V206B and V207A.

(13) *Third frequency divider.* The third frequency divider, V206B and V207A, uses two triode sections of type 12AT7 tubes. It is similar to the second frequency divider and divides its 50-kc input frequency to 10 kc, the desired output frequency. The 10-kc output frequency is fed to 10-kc amplifier V207B.

(14) *10-kc amplifier.* This stage is an isolating amplifier that uses one triode section, V207B, of a type 12AT7 tube. Its 10-kc output is taken from the plate and fed to jack J208 from which it goes to the trigger amplifier on the harmonic selector subchassis.

(15) *Trigger amplifier.* The input to trigger amplifier V301A is a 10-kc sine wave. One section of a dual triode type 5670 is used. The plate load is one winding of the blocking oscillator transformer. The 10-kc signal that appears across the winding is coupled inductively to the grid of blocking oscillator V301B and triggers it into operation.

(16) *Blocking oscillator.* Tube V301B is a single swing blocking oscillator. One section of a type 5670 dual triode tube is used. The blocking oscillator is triggered by the 10-kc signal from the trigger amplifier. The output of the blocking oscillator consists of very sharp pulses at a 10-kc repetition rate. These are fed to pulse shaper amplifier V302.

(17) *Pulse shaper amplifier.* Pulse shaper amplifier V302 uses a pentode tube, type 5725. It is in effect a frequency multiplier stage. The input voltage consists of 10-kc pulses from the blocking oscillator. The output is a selected harmonic of 10 kc (9th to 26th). Selection is made by the HARMONIC NO. switch according to the indication on the PROXY. OSC. dial. The output of this stage is applied to harmonic amplifier V303A.

(18) *Harmonic amplifier.* One-half of a type 5670 dual triode, V303A, is used as a harmonic amplifier. This stage is a voltage amplifier with hf compensation. Compensation is necessary to equalize the amplitudes of the different harmonics present. The output of the harmonic amplifier is coupled to the measure mixer, V304, the operation of which is described in (5) above.

(19) *Horizontal deflection amplifier.* Horizontal deflection amplifier V504 is a paraphase-type push-pull amplifier. It uses both sections of a 12AT7 dual triode tube. Depending on the position of the FUNCTION SW.; two types of input signals may be fed to the horizontal deflection amplifier. In the CAL. position, a selected harmonic (9th to 26th) of 10 kc is the input. In the MEAS. or DIRECT MEAS.

BAND 1 position, the input is a 15- to 20-kc signal. The output of the horizontal deflection amplifier is coupled directly to the horizontal deflection plates of cathode-ray tube V505.

(20) *Cathode-ray tube.* A type 2BP1 2-inch cathode-ray tube, V505, is used for the oscilloscope. A negative high-voltage supply is used to facilitate direct coupling from the amplifiers to the deflection plates and to simplify circuit design. Focus and intensity controls are provided to adjust the scope for suitable presentations.

(21) *Vertical deflection amplifier.* Vertical deflection amplifier V503 is a push-pull, direct-coupled amplifier. It uses both sections of a dual triode tube, type 5751. This amplifier is similar to the horizontal deflection amplifier, but it has greater gain. The input to the vertical deflection amplifier is a 15- to 20-kc saw-tooth voltage. This voltage is applied from buffer amplifier V402 in the interpolation oscillator subchassis.

(22) *Interpolation oscillator.* Interpolation oscillator V401 is a high stability, modified tuned-grid oscillator with a frequency range of 15 to 20 kc. A type 6AU6 tube is used. In measuring frequencies, the oscillator is adjusted to provide a single, closed pattern on the oscilloscope screen, indicating a pattern ratio of 1:1 or zero beat. The INTERPOLATION OSC. dial then is read and a reference frequency is obtained from the calibration book. This number is added to the frequency indicated to the left of the applicable harmonic number on the PROXY. OSC. dial. The sum of these two frequencies is the measured frequency. The output of this stage is applied to buffer amplifier V402.

(23) *Buffer amplifier.* The interpolation oscillator is followed by buffer amplifier V402, a dual triode, type 5670. The purpose of this amplifier is to isolate the interpolation oscillator from load variations. This is done to improve oscillator stability. In addition to its isolation function, the buffer-amplifier stage also contains a wave shaping circuit. It is necessary to improve the shape of the output wave so that a readable Lissajous pattern can be obtained on the oscilloscope. The output of the buffer amplifier is applied to vertical deflection amplifier V503.

d. Complete Block Diagram, Bands 1 through 7, Indirect Measure (fig. 25). A complete block diagram illustrating the operation of Frequency Meter FR–4/U on bands 1 through 7, indirect measure, is depicted in figure 25. Only those stages not previously covered are discussed in (1) through (11) below.

(1) *Proxy oscillator.* Proxy oscillator V101 uses a type 6AU6 pentode tube. This stage is a high stability, tuned-grid oscillator that has a frequency range of 100 to 250 kc. In obtaining a zero beat on bands 1 through 7, the proxy oscillator is adjusted to the unknown frequency (band 1), or to a specified submultiple of the unknown frequency (bands 2 through 7). The output of the proxy oscillator then is substituted (hence the name proxy) for the unknown signal. The output of the proxy oscillator is fed to buffer amplifier V102.

(2) *Buffer amplifier.* Buffer amplifier V102 uses both sections of a dual triode tube, type 12AT7. An output from the cathode of the first section is fed to zero mixer V107 on band 1, when the FUNCTION SW. is in the MEAS. position. An output from the plate of the first section feeds first multiplier V103. The output from the plate of the second section of the buffer amplifier feeds measure mixer V304 when the FUNCTION SW. is in the MEAS. position. The main function of the buffer amplifier is to isolate the proxy oscillator from the mixer and multiplier circuits thus maintaining better oscillator stability.

(3) *First multiplier.* First multiplier V103, a type 6AU6 tube, receives an input frequency from buffer amplifier V102, in the range of 100 to 250 kc.

This frequency is multiplied on bands 2, 3, and 4 by factors of 2, 5, and 10. On bands 2, 3, and 4 the output is fed to zero mixer V107. On bands 2 through 7, the output is fed to limiter amplifier V104. The multiplication factor remains at 10 on bands 4 through 7.

(4) *Limiter amplifier.* Limiter amplifier V104 receives inputs on bands 2 through 7. However, it is only effective on bands 5 through 7 as far as frequency meter operation is concerned. This stage, which uses a type 6AU6 tube, functions to reduce amplitude modulation of the multiplied proxy oscillator frequency. The result is a reduction in spurious responses of the frequency meter. The output of the limiter amplifier is fed to second multiplier V105.

(5) *Second multiplier.* Second multiplier V105 uses a type 6AU6 tube. This stage functions on bands 5 and 6 and receives an input frequency 10 times the proxy oscillator frequency. The second multiplier has multiplication factors of 2 and 4 on bands 5 and 6 respectively. On band 7, the output is the same as on band 6. The output of the stage is fed to zero mixer V107 on bands 5 and 6 and also to third multiplier V106.

(6) *Third multiplier.* Third multiplier V106 receives an input frequency in the range of 4 to 10 mc. This multiplier operates on band 7 only and has a multiplication factor of 2. The output on band 7 is fed to zero mixer V107.

(7) *Zero mixer.* Zero mixer V107 uses a type 5725 tube. There are two inputs to this stage. One is the unknown signal and the other is either the proxy oscillator frequency or an appropriately multiplied harmonic of the proxy oscillator frequency. The output is an audio beat frequency which is the sum or difference of the two input frequencies. This output is sent to the indicator subchassis to provide an aural and a visual indication of the zero beat condition.

(8) *Audio amplifier.* The input to audio amplifier V501A is the audio beat frequency developed in the zero mixer. This stage uses one section of a dual triode tube, type 5751. The amplified audio signals are fed to blinker amplifier V502A and to bucking amplifier V501B.

(9) *Bucking amplifier.* Bucking amplifier V501B operates in conjunction with the audio amplifier to provide volume expansion. On spurious responses of the frequency meter, there is practically no output from the audio amplifier. When the desired response appears, the audio output is increased greatly.

(10) *Blinker amplifier.* Blinker amplifier V502A receives its input signal from the audio amplifier. This stage uses one section of a type 12AT7, dual triode tube. When an audio signal is applied to the blinker amplifier, a neon bulb indicator cycles on and off at the audio frequency to provide a visual means of obtaining zero beat.

(11) *Audio output amplifier.* One section of a dual triode tube, type 12AT7, is used for audio output amplifier V502B. When the bucking amplifier is made substantially inoperative, the output of audio amplifier V501A is applied to the audio output amplifier. The audio output amplifier provides sufficient power output to operate the headset with the required volume.

41. Preselector Amplifier
(figs. 26 and 100)

a. Preselector amplifier V108 selects and amplifies the unknown frequency and applies it to zero mixer V107 and to vtvm V109.

b. The unknown signal frequency to be measured is fed into the frequency meter through SIGNAL INPUT jack J106. The signal is applied to INPUT ATTENUATOR R144 through dc blocking capacitor C147. The INPUT ATTENUATOR is adjusted to provide a reading on the TUNING METER within the green band (30 to 90 va). This setting insures an adequate input signal and prevents over-

loading of the preselector amplifier and zero mixer.

c. The plate of V108 may be connected to any one of seven tank circuits on bands 1 through 7 by BAND SWITCH S101, section 5. Figure 26 depicts the preselector amplifier as set for operation in band 1. Refer to figure 100 for operation on all other bands. This allows the preselector amplifier to be tuned through a range of frequencies from 100 kc to 20 mc. The actual tuning is accomplished by capacitor C144, which is ganged to the proxy oscillator and frequency multiplier tuning capacitors. Each of the seven tank circuits is equipped with a variable polyiron-core slug and a trimmer capacitor to insure accurate frequency calibration and tracking.

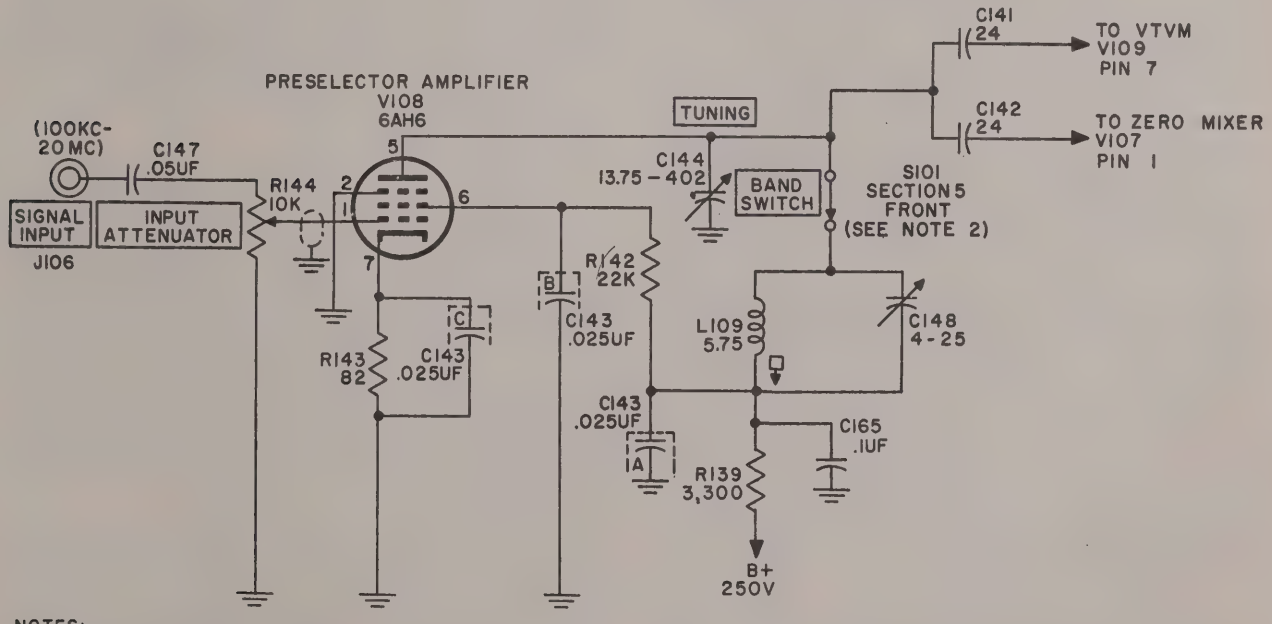
d. Coils L109 through L115 are the tuning inductances on bands 1 through 7, respectively (fig. 100). Each inductance has a trimmer capacitor across it to provide proper tracking and frequency calibration. These trimmer capacitors are designated C148 through C154 on bands 1 through 7, respectively. Resistors R150, R151, R152, R153, and R157 appear in the tank circuits for bands 3 through 7. These resistors reduce the output of V108 at the hf end of the respective bands to prevent overloading the zero mixer.

e. Resistor R143 and capacitor C143C are the cathode bias resistor and cathode bypass capacitor for V108. Screen voltage is dropped by R142 and the screen bypass capacitor is C143B. Plate decoupling is accomplished by resistor R139 and capacitor C143A.

f. The output of V108 is fed to the control grid of zero mixer V107 through coupling capacitor C142 and to vtvm circuit V109 through capacitor C141.

42. Vacuum-tube Voltmeter (figs. 27 and 100)

a. The vtvm circuit is divided on two subchassis. Tube V109 and its input circuits are located on the proxy oscillator-multiplier subchassis. TUNING METER M501 and its associated load resistors are located on the indicator subchassis. This circuit arrange-



NOTES:
1. UNLESS OTHERWISE SHOWN: RESISTORS ARE IN OHMS, CAPACITORS ARE IN UUF INDUCTORS ARE IN MH.
2. S101 SECTION 5 FRONT SHOWN IN BAND 1 POSITION. PLATE TANK CIRCUIT (SUCH AS L109, C148) CHANGES FOR EACH BAND.

TM 5094-24

Figure 26. Preselector amplifier, simplified schematic.

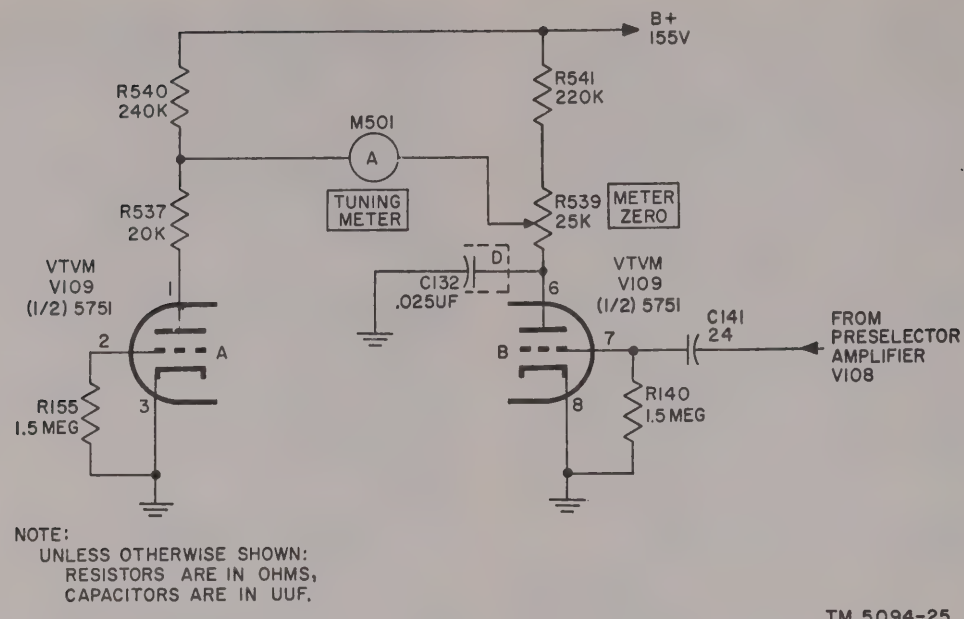


Figure 27. Vacuum-tube voltmeter, simplified schematic.

ment eliminates the need for running a long rf lead between the two subchassis. The TUNING METER is used to indicate the presence of an unknown frequency signal and to measure a rectified voltage proportional to the amplified rf signal.

b. The output of preselector amplifier V108 is applied to the grid (pin 7) of vtvm amplifier V109 through coupling capacitor C141. Rectification is accomplished in the grid to cathode (pins 7 and 8) circuit of V109. The rectified signal appears as a dc voltage across C141, which is applied to the grid (pin 7). The large value of grid resistor R140 insures peak charging of C141. Grid resistor R155 is provided so that the contact bias on each section of V109 will be equal. This makes it possible to maintain meter balance and provide drift-free operation. Capacitor C132D is an rf bypass capacitor. It places the plate (pin 6) at rf ground thus preventing the stage from breaking into the oscillator.

c. Resistors R537, R540, and R541 and METER ZERO variable resistor R539 form part of a bridge circuit that is completed by V109. With no input signal to V109, METER ZERO control R539 is adjusted so that equal potentials exist at each terminal of meter M501 and the meter reads zero. When a signal is applied to the frequency meter, a negative voltage will be developed at the grid side of C141, reducing the plate current in the B section of V109 and in resistors R539 and R541. This action causes the potential at the positive terminal of the TUNING METER to become more positive and the meter needle to deflect in proportion to the strength of the input signal.

43. Zero Mixer

(figs. 28 and 100)

a. The function of zero mixer V107 is to heterodyne the unknown signal and the direct or multiplied signal from the proxy oscillator to determine their frequency relation. When zero beat is obtained, the proxy oscillator is set exactly to the unknown signal (band 1) or to an exact submultiple of the unknown signal (bands 2 through band 7). On band 1 through band 7, the output of the proxy oscillator is substituted for the unknown signal in measure mixer V304.

b. The unknown frequency signal is applied to the control grid (pin 1) of V107 by the grid coupling network which consists of coupling capacitor C142 and grid resistor R141. The direct or multiplied signal of the proxy oscillator is applied to the suppressor grid (pin 7) of V107. This signal is brought in through coupling capacitor C135 and developed across suppressor grid resistor R136. The cathode of V107 is grounded and bias is developed by the flow of grid current through R141. This pro-

vides the nonlinear-type operation that is required for heterodyning action. Plate decoupling is provided by capacitor C137. Resistor R132 is used as the screen dropping resistor and capacitor C143D is used as the screen bypass capacitor.

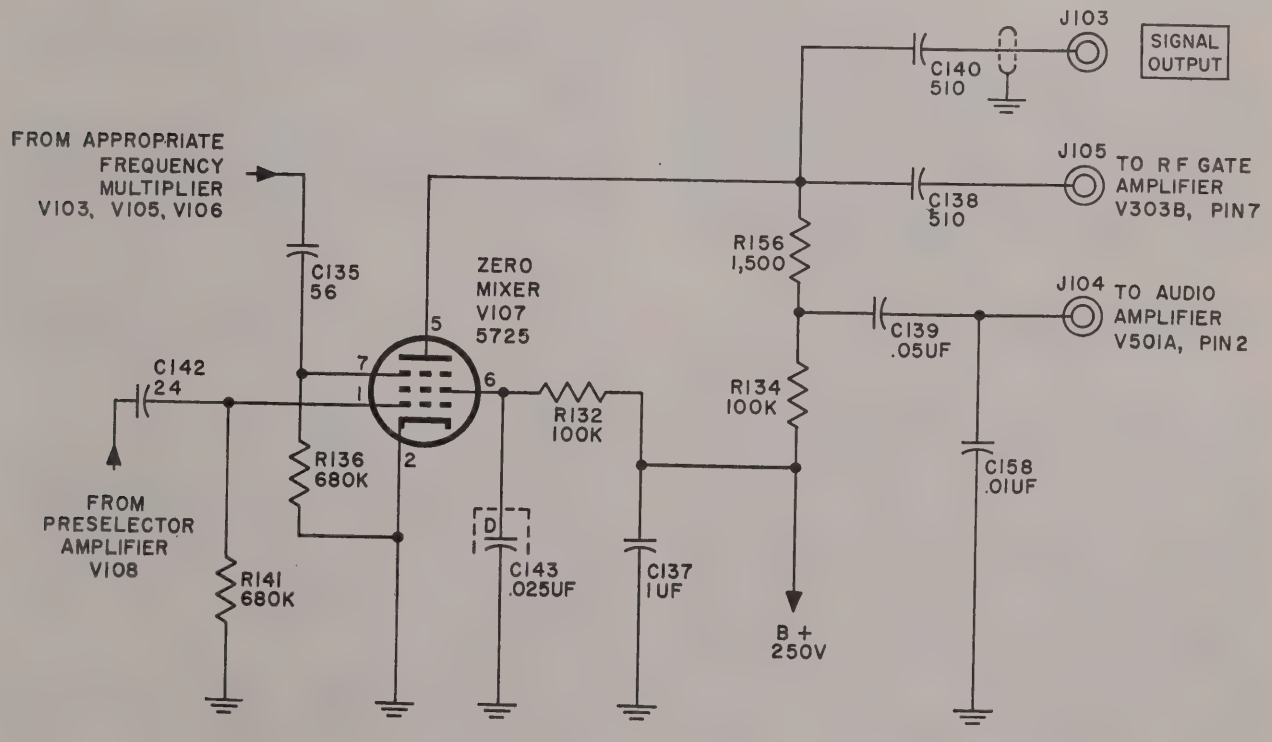
c. The heterodyne (audio) frequency output is tapped off at the junction of the two series plate-load resistors R134 and R156. Rf components of the heterodyne signal are bypassed by capacitor C158. Capacitor C139 couples the audio component of the signal to jack J104 and to the audio amplifier on the indicator subchassis.

d. Two other outputs are taken from the plate circuit of the zero mixer. One of these is applied through coupling capacitor C140 to SIGNAL OUTPUT jack J103, located on the front panel. This jack is used whenever the frequency meter is used as a signal generator. The third output is coupled through capacitor C138 to jack J105. From this jack, the signal is applied to the grid of rf gate amplifier V303B (on the harmonic selector subchassis) for use on DIRECT MEAS. BAND 1 only.

44. Rf Gate Amplifier
(figs. 29 and 100)

a. When BAND SWITCH S101 is set to BAND 1 and FUNCTION SW. S301 is set to DIRECT MEAS. BAND 1, rf gate amplifier V303B is energized by the application of plate voltage. Plate voltage is applied through contacts on switches S101 (section 1 rear) and S301 (section 3).

b. The input to the grid of rf gate amplifier V303B comes from zero mixer V107 and is brought in through plug P305. The signals are developed across grid resistor R322. Although signals are applied to the grid on all seven bands, the rf gate amplifier is energized only on band 1 as described in *a* above.



NOTE:
UNLESS OTHERWISE SHOWN:
RESISTORS ARE IN OHMS,
CAPACITORS ARE IN UUF.

TM 5094-26

Figure 28. Zero mixer, simplified schematic.

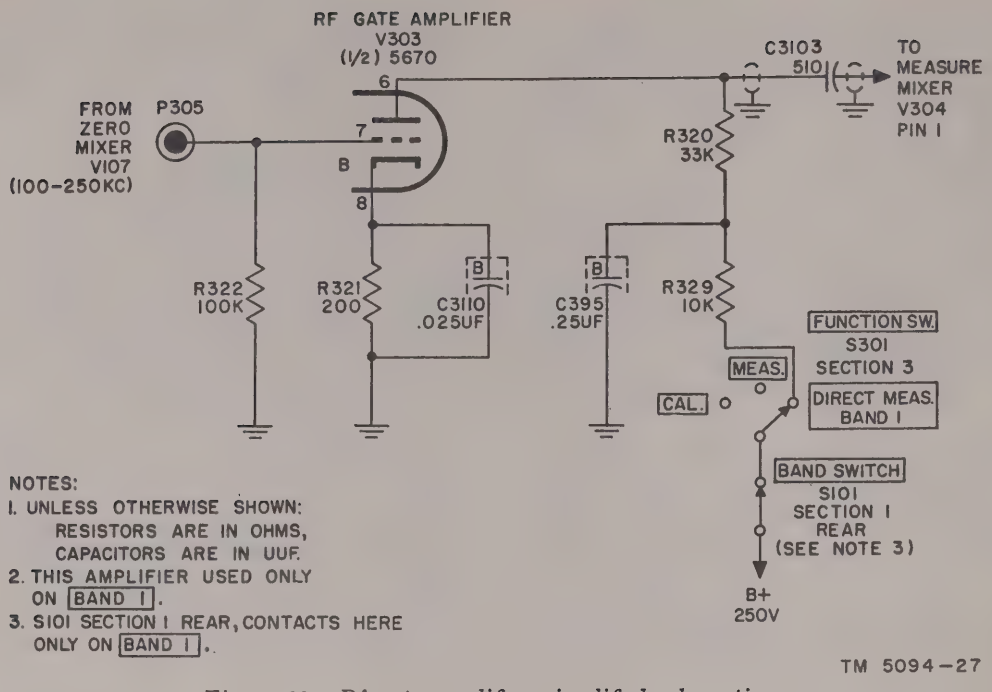


Figure 29. Rf gate amplifier, simplified schematic.

c. The amplified signal is developed across plate load resistor R320 and applied through coupling capacitor C3103 to the grid (pin 1) of measure mixer V304. Plate decoupling is accomplished by resistor R329 and capacitor C395B. Resistor R321 and capacitor C3110C provide cathode bias for this stage.

45. Measure Mixer
(figs. 30 and 100)

a. Two signals are fed to measure mixer V304; one is fed to the suppressor grid (pin 7) and the other to the control grid (pin 1). The signal applied to the suppressor grid from harmonic amplifier V303A is a selected harmonic of 10 kc and ranges from the 9th to the 26th. The harmonic, chosen by HARMONIC NO. switch S303, is determined by the harmonic number scale on the PROXY. OSC. dial. The other signal applied to the control grid (pin 1) of measure mixer V304 is supplied from one of two possible sources. With the FUNCTION SW. in the MEAS. position, the input signal is applied from buffer amplifier V102 to the control grid of the measure mixer. When the FUNCTION SW. is set to the DIRECT MEAS. BAND 1 position and the BAND SWITCH to BAND 1, the input signal is applied to the control grid of the measure mixer from the plate circuit of rf gate amplifier V303B.

b. During the operation of the frequency meter, the correct harmonic of 10 kc is selected. When this harmonic is heterodyned in the measure mixer with the 100- to 250-kc input signal, it will produce a difference frequency in the range of 15 to 20 kc. The plate circuit of V304 contains a variety of frequencies including the two original input frequencies and their sum and difference frequencies. All of these frequencies are developed across plate load resistor R324. The difference frequencies are selected by band-pass filter FL301, because these fall in the range of the interpolation oscillator (15 to 20 kc). By using band-pass filter FL301 as a coupling device, the 15- to 20-signal is coupled to the control grid of 15- to 20-kc amplifier V305.

c. The suppressor grid signal is applied to V304 through coupling capacitors C397 and C399 (fig. 100). By the action of voltage divider networks R331 and R314, this signal is divided by a factor of approximately 8 before being applied to the suppressor grid. Cathode bias is supplied by resistor R316 and capacitor C3109A. The correct screen grid voltage is obtained by a voltage divider that consists of resistors R318 and R332. Capaci-

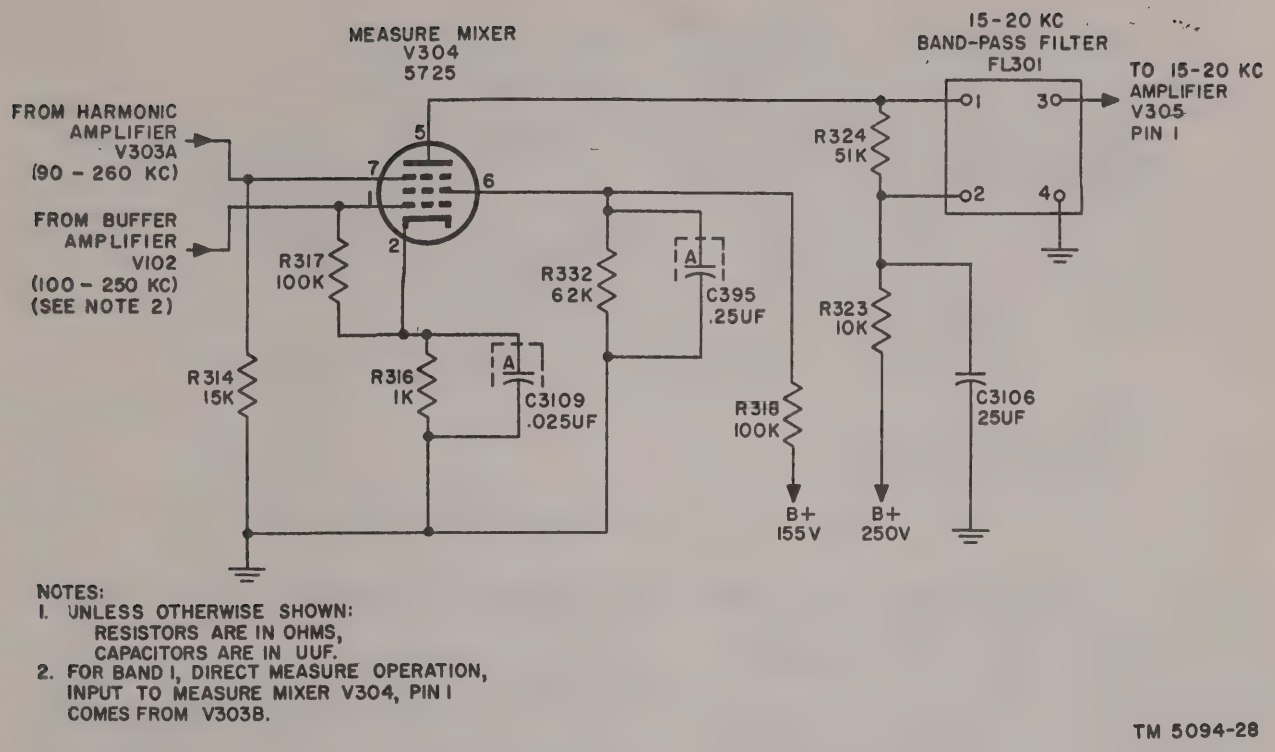


Figure 30. Measure mixer, simplified schematic.

tor C395A bypasses the screen grid for all applied and developed frequencies. Plate decoupling is provided by resistors R323 and capacitor C3106.

46. Amplifier (15- to 20-kc)
(figs. 31 and 100)

The 15- to 20-kc amplifier (V305) provides the correct impedance termination for the 15- to 20-kc filter. In addition, it amplifies the 15- to 20-kc signal from band-pass filter FL301. This stage uses a triode-connected pentode tube with the screen grid tied to the plate. Cathode resistor R327 is unbypassed to supply a degenerative bias. This improves amplifier frequency response and reduces distortion that may be introduced by V305. The output signal from V305 is developed across plate resistor R326 and fed through coupling capacitor C3105 to the FUNCTION SW. In the MEAS. or DIRECT MEAS. BAND 1 position of S301, the 15- to 20-kc output signal is fed through jack J314 to horizontal deflection amplifier V504. In the CAL. position of S301, there is no output from V305 to the oscilloscope. In this latter position, the output of harmonic amplifier V303A is applied to the horizontal deflection amplifier.

47. Crystal Oscillator
(figs. 32 and 100)

a. Crystal oscillator V202 provides the highly stable measuring and calibrating signals of Frequency Meter FR–4/U. To insure maximum frequency stability, the crystal is inclosed in a sensitive temperature-controlled oven.

b. The crystal oscillator is a Pierce type with the crystal connected between the plate and control grid of V202. The crystal is a CR–36/U type which operates at precisely 1,250 kc. Trimmer capacitors C206 and C239 are used to adjust the oscillator frequency to 1,250 kc, as checked against radio station WWV or any other primary frequency standard. The amount of feedback is determined by the capacity divider network which consists of capacitors C202, C203, C204, and C205. These same capacitors are effectively shunted across the interelectrode capacitances of V202. Because they are considerably larger than the interelectrode capacitances, they greatly reduce the effect on the operating frequency of any inter-

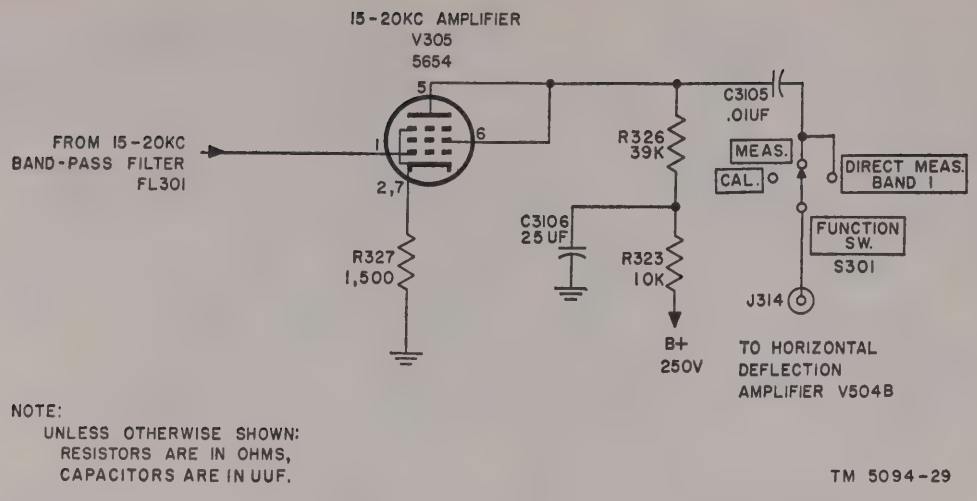


Figure 31. Amplifier (15- to 20-kc), simplified schematic.

electrode capacitance changes. The crystal proper is partially isolated from V202 by capacitors C202 and C205. The isolation improves frequency stability.

c. The crystal oven is equipped with fine and coarse thermostatically controlled heaters. For small deviations in temperature from the desired average value, only the fine heater is actuated. For more rapid starting heat or for larger deviations from the desired temperature, both the fine and coarse heaters are actuated simultaneously. Operation of the oven heaters is indicated by OVEN HEATER lamp I 201, which is in series with one side of the ac supply to the oven. Lamp I 201 glows with medium intensity when the equipment is first turned on, because the coarse and fine thermostats are both closed to place the relatively low resistance of the paralleled coarse and fine heaters in series with the lamp. When the oven approaches the desired operating temperature, the coarse thermostat opens and only the fine

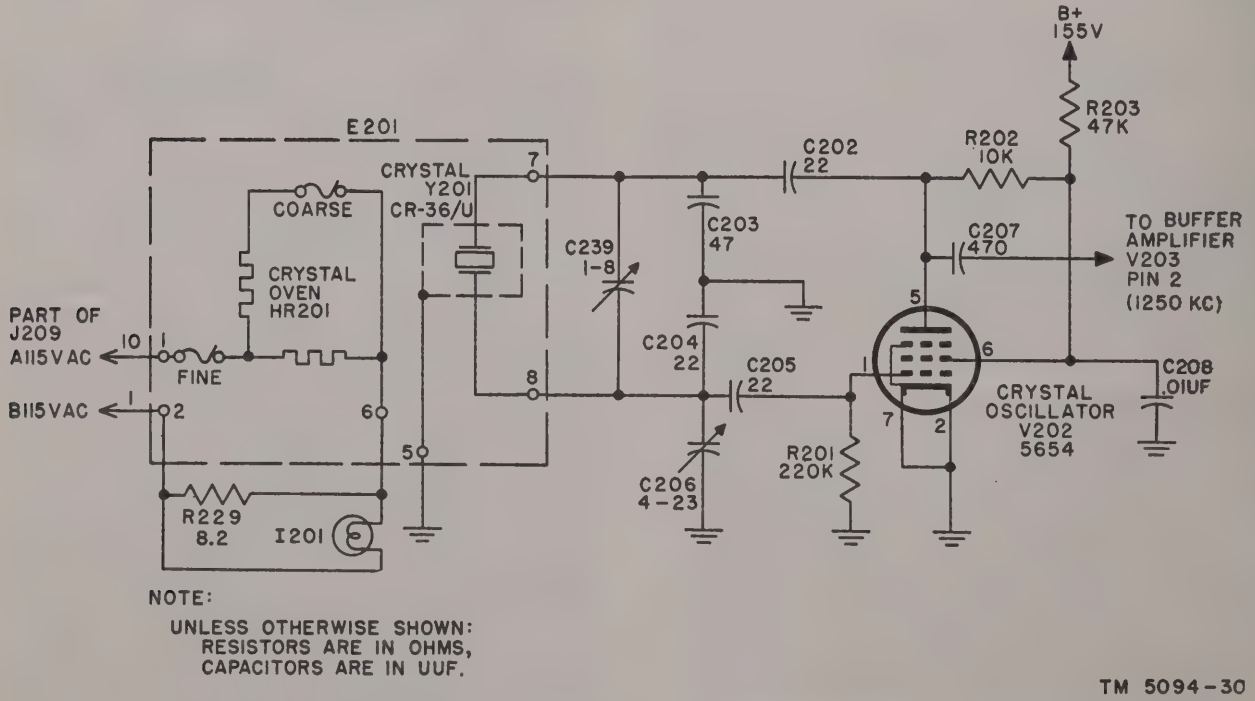


Figure 32. Crystal oscillator, simplified schematic.

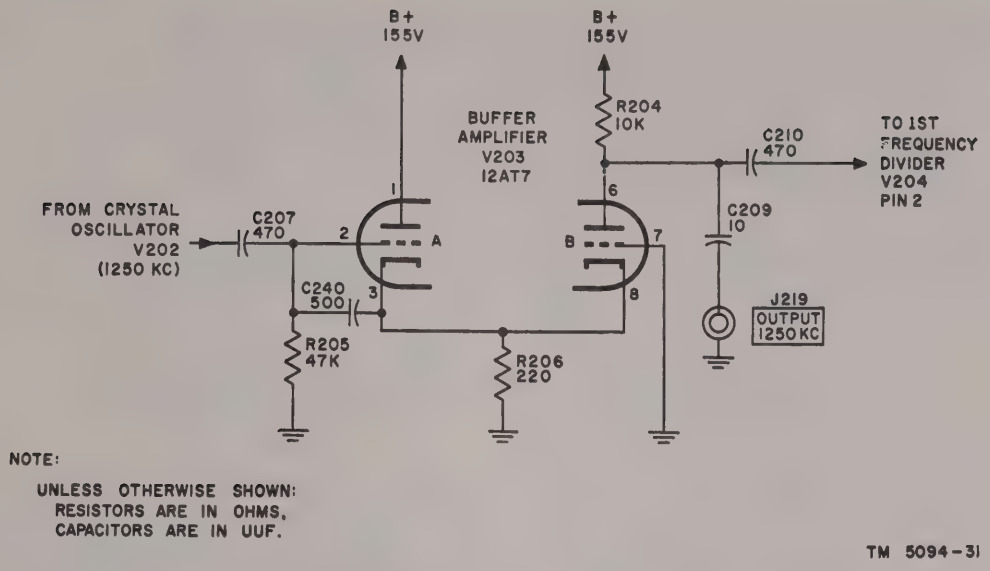


Figure 33. Buffer amplifier for crystal oscillator, simplified schematic.

thermostat is closed. The higher resistance of the fine heater reduces the current through the lamp, and thus causes it to dim. Thereafter, I 201 normally cycles between dim and off as the fine thermostat is actuated to control the temperature of the oven. Resistor R229, across I 201, provides a parallel path for the heater current and permits I 201 to operate within its current rating for all heater operations.

d. The output of the crystal oscillator stage is developed across plate load resistor R202 and coupled to buffer amplifier V203 through coupling capacitor C207. Screen grid voltage is obtained through screen dropping resistor R203, and the screen is bypassed by capacitor C208. Capacitors C201 and C238 (fig. 100) decouple the plate and screen circuits of V202 from the power supply. Grid resistor R201 provides a grid to cathode dc return and determines the amount of grid leak bias developed by the oscillator.

48. Buffer Amplifier
(figs. 33 and 100)

Buffer amplifier V203 isolates the crystal oscillator from the frequency dividers and from the frequency measurement equipment when using OUTPUT 1250 KC jack J219 to monitor the crystal oscillator frequency. The input signal is developed across grid resistor R205 and applied to the grid of the first section of the buffer amplifier, which is a cathode follower. The output of the cathode follower is developed across cathode resistor R206. Because the output of the cathode follower by itself would not be large enough to drive the buffer amplifier and frequency divider, a portion of the input signal from the crystal oscillator is fed through capacitor C240 to resistor R206. The two signals aid each other because the grid and cathode are of the same place relation. The second section of the buffer amplifier is a grounded-grid amplifier. The input signal to this section is developed across the common cathode resistor R206. The output appears across plate load resistor R204 and is fed to the grid of first frequency divider V204 through coupling capacitor C210. Capacitor C209 is used for blocking dc when an output from jack J219 is desired.

49. First Frequency Divider
(figs. 34, 35, and 100)

a. Three similar frequency dividers of the regenerative type are used to reduce the frequency of the crystal oscillator from 1,250 kc to 10 kc. Since a total frequency division of 125 is required, each divider will be divided by a factor of five. The basic principles of operation of any of the three dividers may be explained with reference to the simplified block diagram (fig. 35), which illustrates the operation of first frequency divider V204. The fundamental frequency ($f = 1{,}250$ kc) is ap-

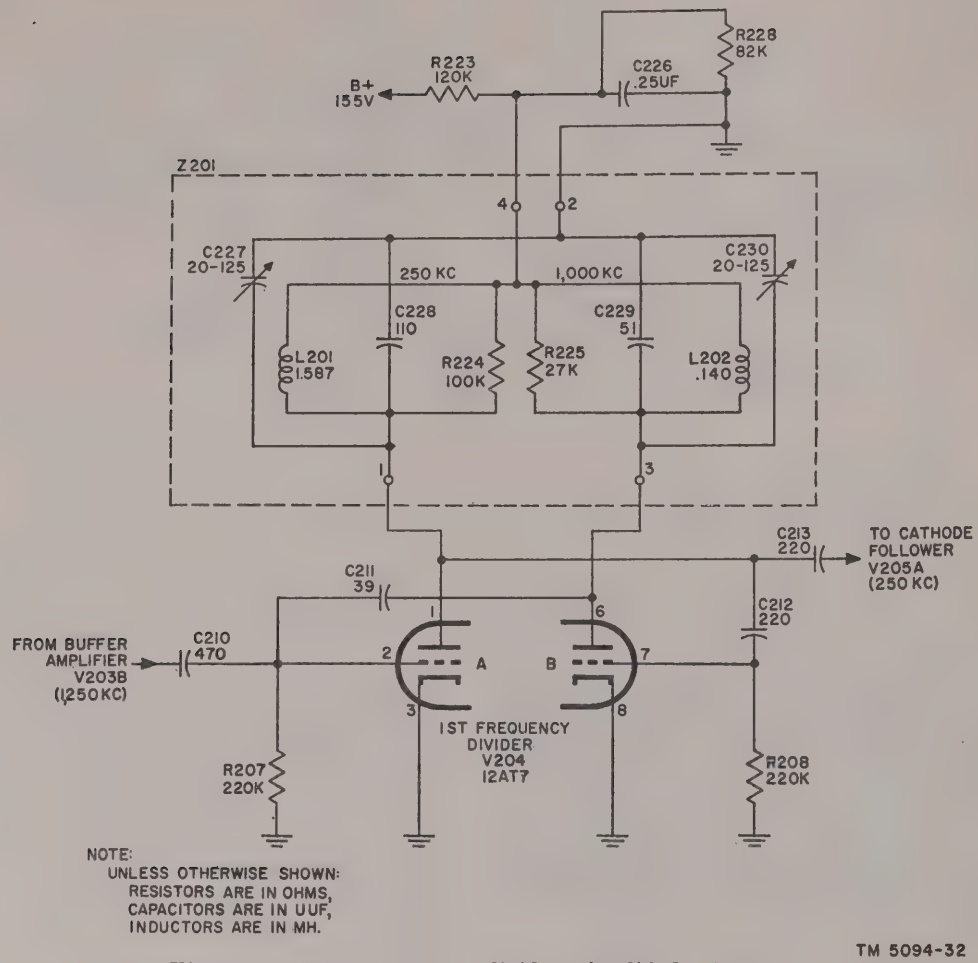


Figure 34. First frequency divider, simplified schematic.

plied to the mixer. The amplified fundamental then shock excites a tank circuit in the plate (tuned to $\frac{f}{5}$ or 250 kc); this signal is fed to a multiplier whose output is four times its input (4 x 250 = 1,000 kc). The output of the multiplier is fed to the grid of the mixer. The input signal (1,250 kc) is then beat with the output of the multiplier (1,000 kc). The resultant (250 kc) voltage, developed in the plate circuit, thus reinforces the oscillating current set up initially in the plate tank.

b. The input signal to the first frequency divider is applied to the grid (pin 2) of V204 and developed across grid resistor R207. The frequency divider consists basically of mixer tube V204A and frequency multiplier V204B. The divided output is taken from the plate of the mixer tube.

c. The fundamental input frequency (1,250 kc) is applied to the grid (pin 2) of mixer V204A. The 1,250-kc signal shock excites the plate tank circuit of the mixer, which consists of capacitors C227 and C228, resistor R224, and coil L201. The tank circuit is tuned to operate at 250 kc, or one-fifth of the fundamental frequency. The 250-kc output from the plate of the mixer is coupled through capacitor C212 to the grid (pin 7) of frequency multiplier V204B. In V204B, the 250-kc signal is multiplied by 4 and becomes 1,000 kc in the plate tank circuit of the multiplier. This tank circuit is composed of capacitors C229 and C230, resistor R225, and coil L202. The 1,000-kc signal is fed back through C211 to the grid (pin 2) of the mixer. At this time, there is present at the grid (pin 2) the fundamental frequency (1,250 kc) and the 1,000-kc frequency. These two frequencies are heterodyned in the mixer and produce a difference frequency of 250 kc, which is the operating frequency of the mixer tank circuit.

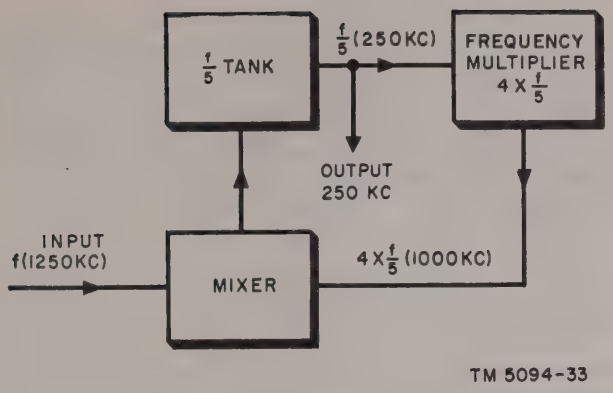


Figure 35. Frequency divider, simplified block diagram.

d. The divider circuit is regenerative, but it is prevented from becoming free running by restricting the amplitudes of the signals applied to each grid and by operating with low plate voltages. If the circuit were free running, there would be an output from the crystal oscillator divider subchassis even if the crystal oscillator ceased operation. This would result in false measurements being made by the frequency meter. In addition, if the divider were free running, it might not remain under control of the crystal oscillator and would tend to be unstable in operation.

e. To improve the stability of the first divider, the two tank circuits are resonated just below their operating frequencies. The mixer (V204A) tank is resonated at 242 kc and the frequency multiplier (V204B) tank is resonated at 975 kc. Both tank circuits offer capacitive reactance at their operating frequencies, and thus eliminate the tendency of the frequency divider to free run.

f. The output of the divider is taken from the plate of the mixer and coupled through capacitor C213 to the grid of cathode follower V205A. Plate circuit decoupling for V204 is provided by resistor R223 and capacitor C226. Resistor R208 is the grid return resistor for V204B.

50. Cathode Follower
(figs. 36 and 100)

The grid circuit of cathode follower V205A receives a 250-kc signal from the first frequency divider. The output is developed across cathode resistor R210 and fed through coupling capacitor C215 to the grid (pin 7) of the second frequency divider. The function of this cathode follower stage is to isolate the first and second frequency dividers, and thus improve the stability of the dividing circuits. Capacitor C214 and resistor R209 limit the amplitude of the undesired hf components.

51. Second Frequency Divider
(figs. 37 and 100)

a. Second frequency divider V205B and V206A operates in a manner similar to that of first frequency divider V204. V205B is the mixer stage and V206A is the frequency multiplier.

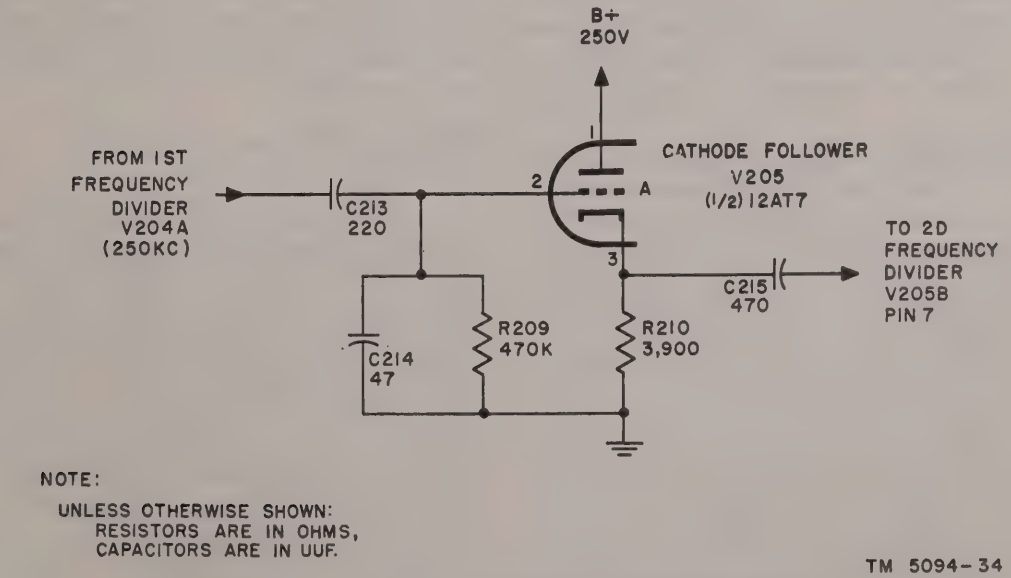


Figure 36. Cathode follower, simplified schematic.

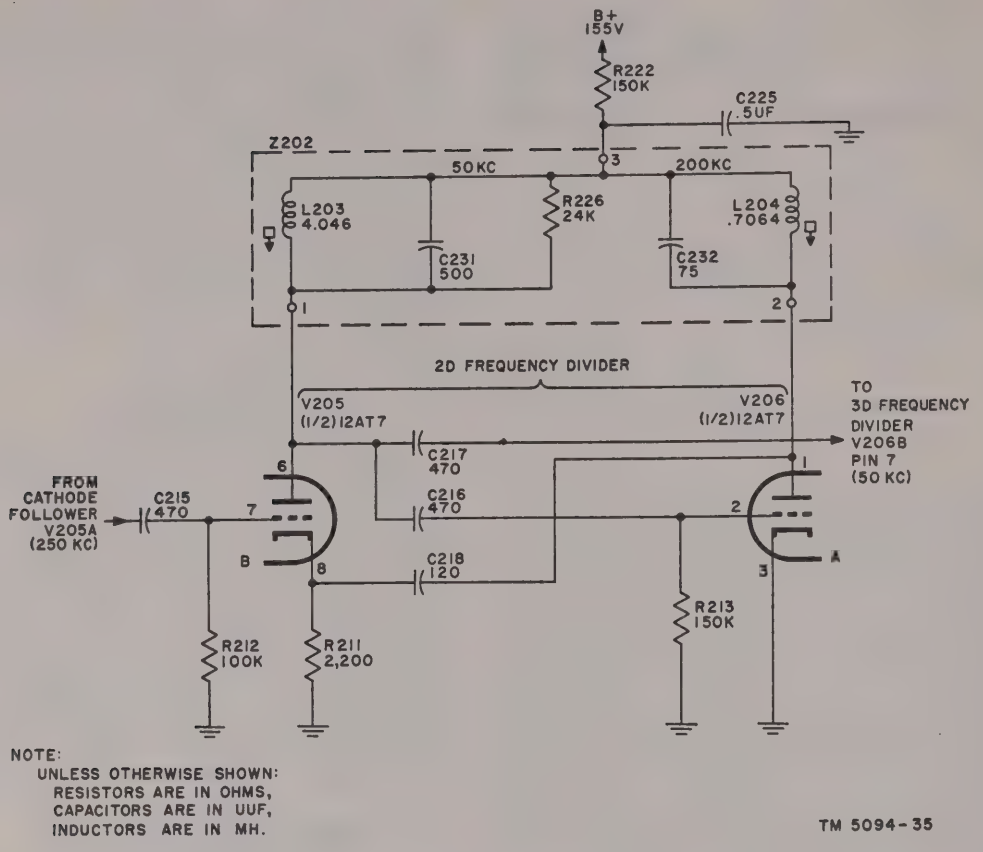


Figure 37. Second frequency divider, simplified schematic.

b. The input signal at a frequency of 250 kc is impressed across grid resistor R212 and applied to the grid (pin 7) of mixer V205B. The mixer plate tank circuit operates at 50 kc, and the frequency multiplier V206A plate tank circuit operates at 200 kc. The mixer receives frequencies of 250 kc and 200 kc and produces a 50-kc difference frequency to operate its plate tank.

c. As in the case of the first frequency divider, the two plate tank circuits are resonated off their operating frequencies to provide improved stability. The mixer tank, which consists of capacitor C231, coil L203, and resistor R226, is resonated at 57 kc. The frequency multiplier tank, which consists of capacitor C232 and coil L204, is resonated at 214 kc. Inductive tuning rather than capacitive tuning is required to provide stability for this divider, because the output of frequency multiplier V206A is returned to the cathode of mixer V205B (pin 8) rather than to the mixer grid.

d. The mixer is coupled to the frequency multiplier section by capacitor C216. Coupling between the plate of the frequency multiplier and the cathode of the mixer is accomplished by capacitor C218. The 50-kc output of the mixer is coupled through capacitor C217 to the third frequency. Resistor R211 is the cathode load resistor for V205B. Plate circuit decoupling is provided by resistor R222 and capacitor C225.

52. Third Frequency Divider
(figs. 38 and 100)

a. Third frequency divider V206B and V207A is almost identical with second frequency divider V205B and V206A, except for frequencies and component values used. The input to mixer V206B is developed across grid resistor R215 at a frequency of 50 kc. The mixer plate tank circuit operates at 10 kc and consists of capacitors C237 and C233, resistor R227, and coil L205. The mixer plate output is coupled to the grid (pin 2) of frequency multiplier V207A through capacitor C219. Resistor R216 is the grid return resistor. Capacitor C235 attenuates undesired hf components.

b. The frequency multiplier plate tank circuit operates at 40 kc. This tank circuit is made up of capacitor C234 and coil L206. The output of the frequency multiplier is coupled through capacitor C221 to the cathode (pin 8) of V206B. This 40-kc signal is developed across cathode resistor R214. Resistor R221 and capacitor C224 form a plate decoupling network for the third frequency divider.

c. The resonant frequencies used are 42.75 kc for frequency multiplier V206B and 10.7 kc for mixer V207A. The 10-kc output is taken from the plate (pin 6) of the mixer and coupled through capacitor C220 and resistor R219 to the grid of 10-kc amplifier V207B.

53. Amplifier (10-kc)
(figs. 39 and 100)

The input to 10-kc amplifier V207B is a 10-kc wave from the third frequency divider. The input wave is applied to the grid (pin 7) across grid resistor R218. Capacitor C236 bypasses the undesired high frequencies. The output signal (10-kc) is developed across plate load resistor R220 and is coupled to output jack J208 through capacitor C222. Capacitors C223 and C222 form a voltage divider to reduce the amplitude of the output signal. In addition, C223 provides some attenuation for undesired hf components. The 10-kc output signal is sent from jack J208 to trigger amplifier V301A.

54. Trigger Amplifier
(figs. 40 and 100)

a. Trigger amplifier V301A receives a 10-kc sine wave input from the 10-kc amplifier. This input is fed through plug P308 and applied across grid resistor R301 to the grid (pin 3) of V301A. Capacitor C390A places one end of R301 at ground potential for signal frequencies. By connecting grid resistor R301 to the junction of R303 and R304, bias for this stage is furnished by resistor R303, and cathode bypassing is provided by capacitor C390B.

b. The amplified 10-kc sine wave appears across plate winding 3–6 of blocking oscillator

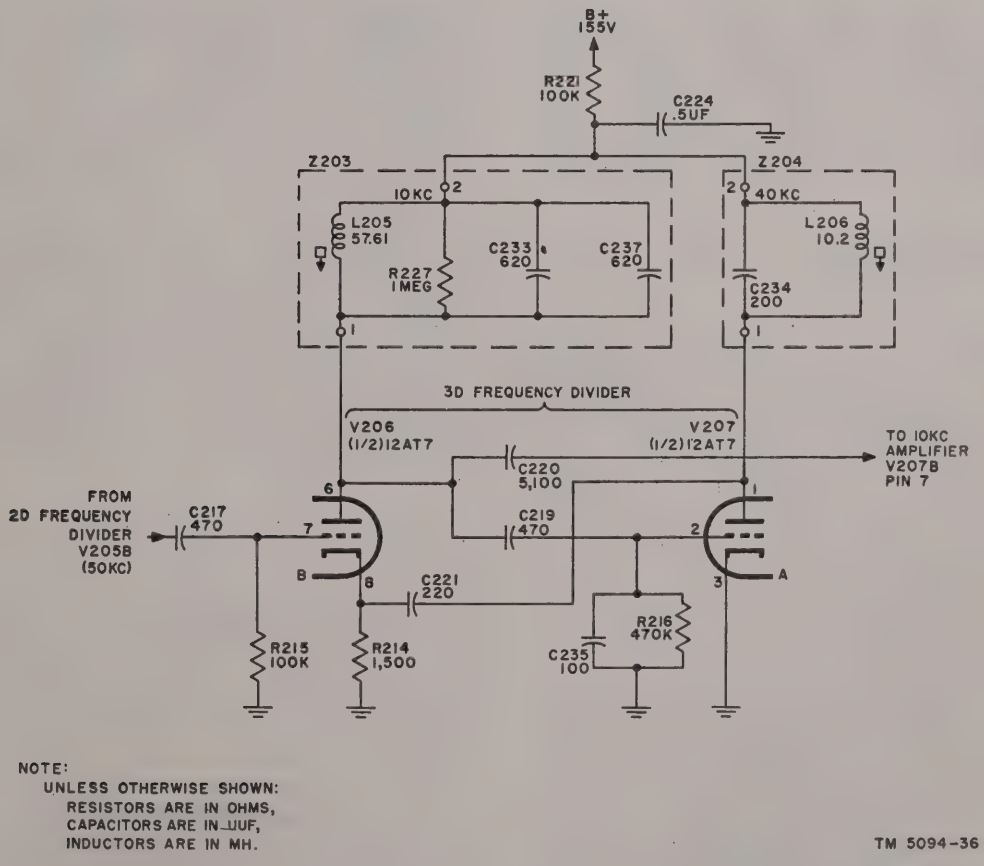


Figure 38. Third frequency divider, simplified schematic.

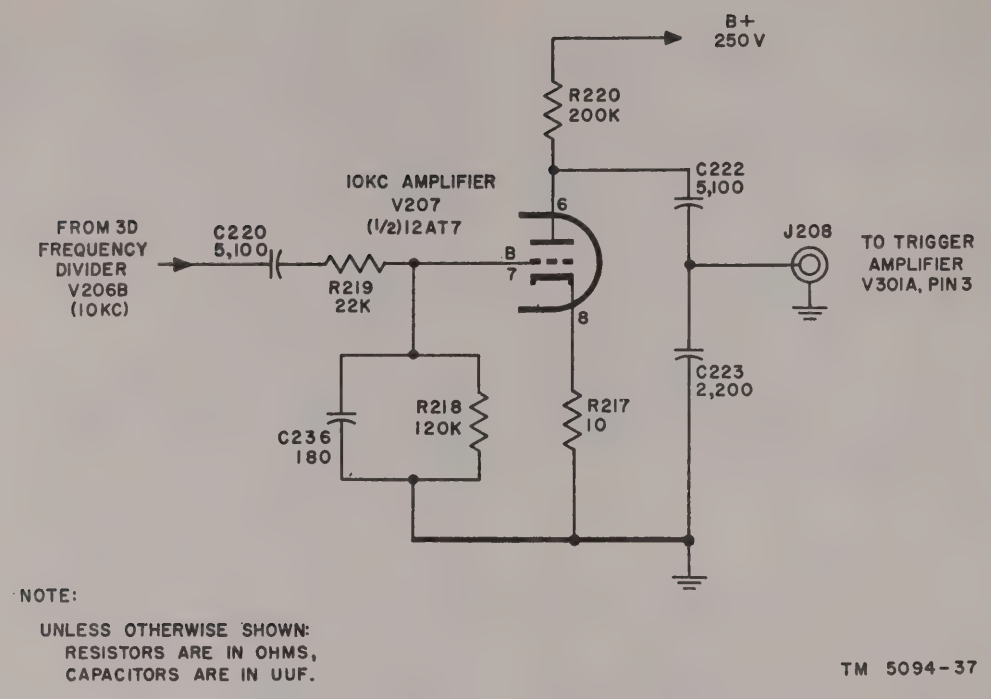


Figure 39. Amplifier, 10 Kc, simplified schematic.

transformer T301 and is inductively coupled through the grid winding 1–4 to the grid (pin 7) of blocking oscillator V301B. The positive portion of the 10-kc wave has sufficient amplitude to trigger the blocking oscillator. Plate decoupling for the trigger amplifier is provided by resistor R306 and capacitor C3109B.

55. Blocking Oscillator
(figs. 40 and 100)

a. In the absence of a triggering impulse, blocking oscillator V301B is in a nonoperating state. It is kept this way by fixed bias from the plus 250-volt voltage divider network comprised of resistors R333, R305, and R304. The blocking oscillator is triggered into operation by the positive portion of the 10-kc sine wave coupled through T301 from the trigger amplifier. Because the blocking oscillator produces an output only when triggered, it operates at a repetition frequency of exactly 10 kc.

b. Because of the short time constant of grid bias resistor R307 and capacitor C392, the stage returns to its nonoperating state considerably before the next positive sinusoidal triggering voltage appears at the grid (pin 7) of V301B. A blocking oscillator of this type is used to produce an extremely narrow and high amplitude pulse that is capable of driving a multiplier circuit efficiently to at least the 26th harmonic of 10 kc. Because the narrow pulses from the blocking oscillator are crystal controlled, the repetition frequency is exactly 10 kc, and this insures accurate harmonic frequency generation.

c. The output of blocking oscillator V301B is coupled through capacitor C393 to the grid (pin 1) of pulse-shaper amplifier V302. The output is also applied through capacitor C391 to the OUTPUT 10 KC jack J318. The narrow 10-kc pulse can be used as a convenient reference signal for laboratory use and for aid in troubleshooting.

56. Pulse-Shaper Amplifier
(figs. 41 and 100)

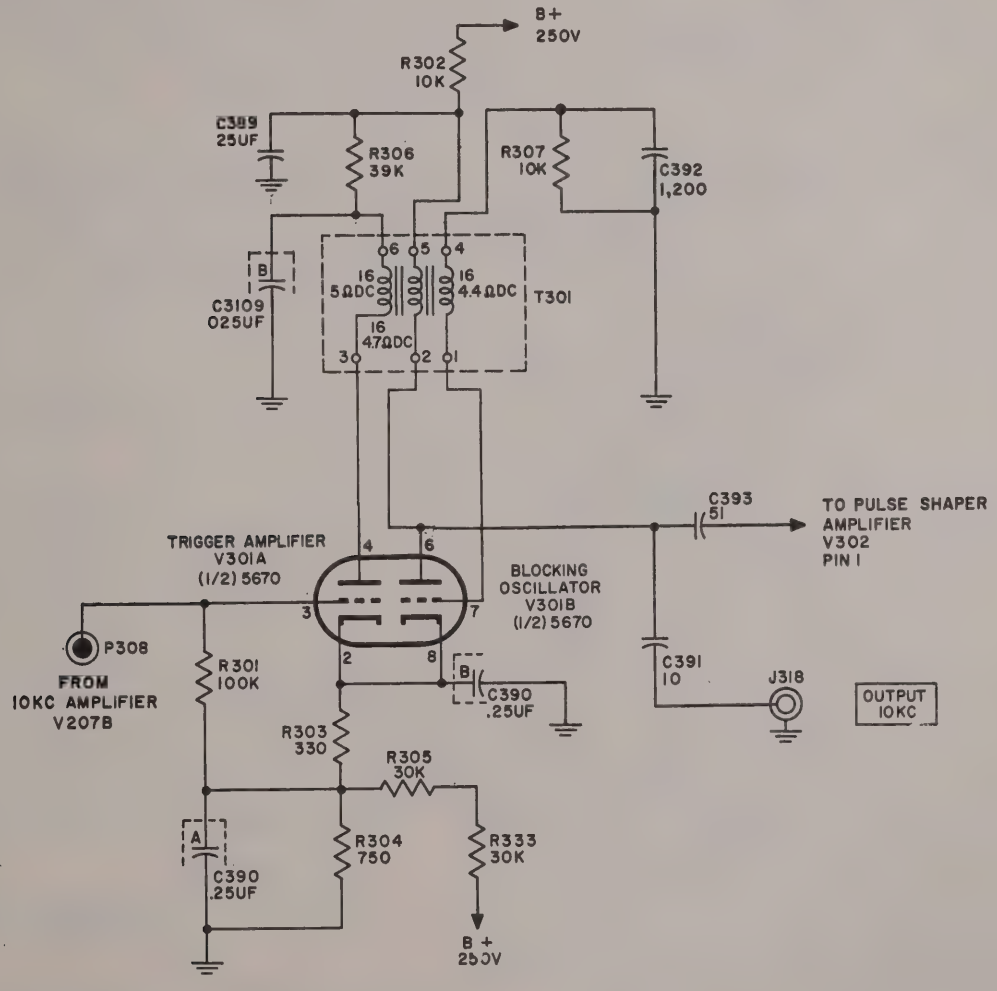
a. Pulse-shaper amplifier V302 is, in effect, a frequency multiplier stage. The input to this stage consists of the narrow 10-kc pulses from the blocking oscillator. The output is a selected harmonic of 10 kc ranging from the 9th through the 26th.

b. The input signal is applied across coil L301, which peaks the signal and also provides a rapid discharge path between pulses for C393. The latter function is necessary because C393

charges up from grid current on each pulse. Resistor R308 is a damping resistor for coil L301 to prevent oscillations.

c. In the absence of an input pulse, V302 is almost at cutoff because of large cathode resistor R310 (9,100 ohms). When a 10-kc pulse appears on the grid of V302, a sharp pulse of plate current flows and shock excites the tuned plate circuit at the frequency of the selected harmonic. The tuned plate circuit of V302 consists of coil L302 in parallel with any one of 18 groups of tuning capacitors. In figure 41, HARMONIC NO. switch S303 is shown in the 9th harmonic position. In this position, the tuning capacitors for L302 consist of C301, C303, C3112, and C305 in parallel. Capacitor C301 has a negative temperature coefficient to improve the stability of the tuned circuit.

d. The amplitude of the various harmonic outputs must not change appreciably because such changes would vary the horizontal dimensions of the oscilloscope pattern. The horizontal oscilloscope pattern dimensions are held constant within 10 percent on all harmonic settings by amplitude compensation. Compensation is accomplished in such a manner that the output at the higher harmonics is boosted. Part of the compensation is provided by undercoupling T302 at the lower harmonics. The effective coupling increases with frequency and tends to maintain a constant amplitude over the range of harmonics.



NOTE:
UNLESS OTHERWISE SHOWN:
RESISTORS ARE IN OHMS,
CAPACITORS ARE IN UUF,
INDUCTORS ARE IN MH.

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Figure 40. Trigger amplifier and blocking oscillator, simplified schematic.

e. On the 10th through 26th harmonic, the tuning capacitors for L302 are as follows:

Harmonic	Capacitors
10th	C307, C309, C3113, C111
11th	C313, C315, C3117, C3115
12th	C317, C3135, C319, C3119
13th	C321, C323, C3123
14th	C3127, C327, C325
15th	C329, C331, C3129, C333
16th	C335, C337, C339
17th	C341, C343, C345
18th	C347, C349, C3131
19th	C351, C353, C3133
20th	C355, C357, C359
21st	C361, C363, C3137
22d	C365, C367, C3139
23d	C369, C371, C3141
24th	C373, C375, C377
25th	C379, C381, C383
26th	C385, C3143, C387

f. Plate decoupling is provided by capacitor C3108 and resistor R311. The screen grid is bypassed by capacitor C3110A and screen grid voltage is dropped by resistor R309. Cathode bias is provided by resistor R310 bypassed by capacitor C3109C. The output of V302 is coupled by transformer T302 to harmonic amplifier V303A.

57. Harmonic Amplifier

(figs. 41, 42, and 100)

a. The signal input circuit of harmonic amplifier V303A is similar to the tuned plate circuit of V302 (fig. 41). It consists of fixed inductance L303, which is inductively coupled to coil L302. Coil L303 is resonated by one of 18 sets of tuning capacitors as selected by section 1 of HARMONIC NO. switch S303. The tuning capacitors are temperature-compensated for improved stability.

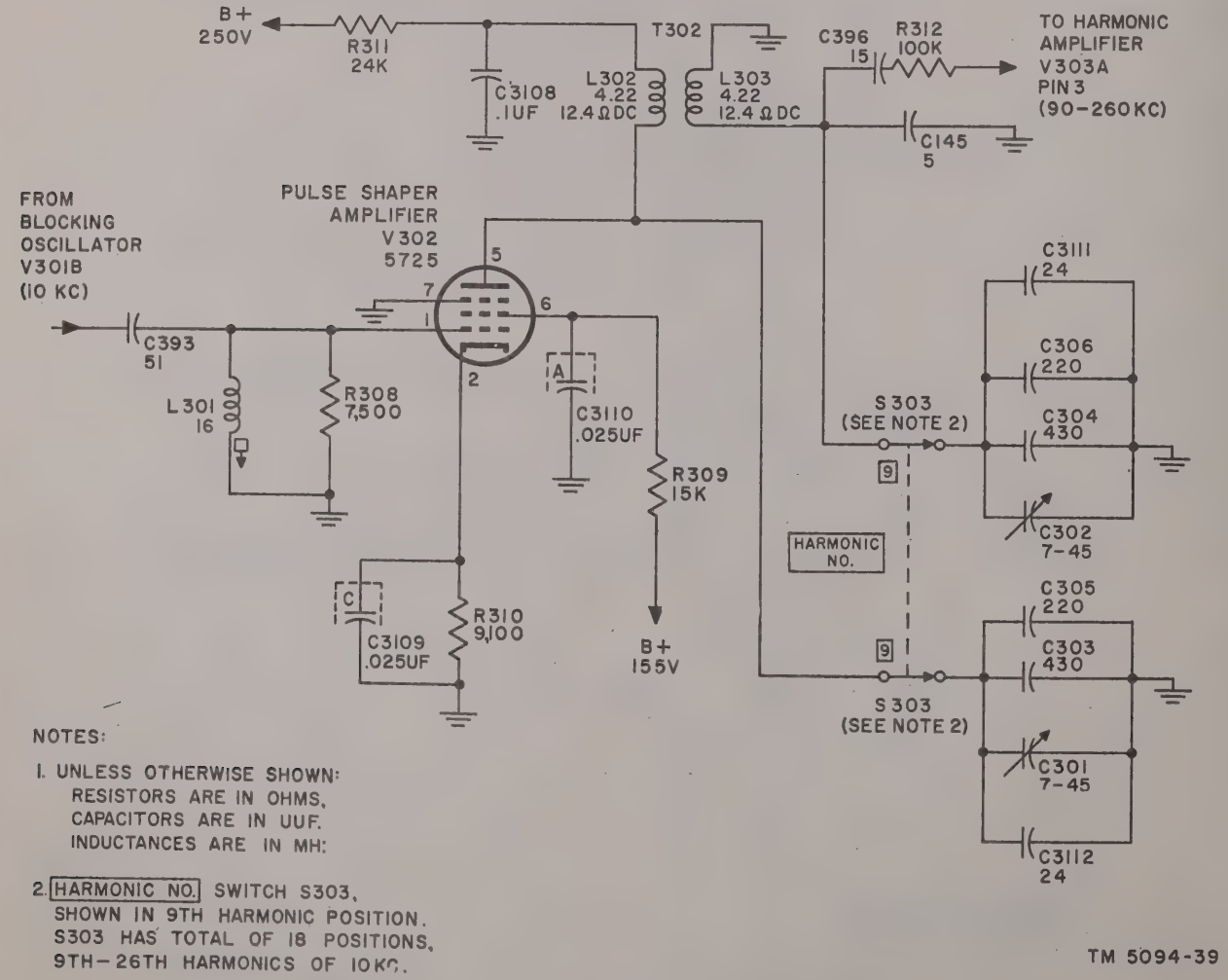


Figure 41. Pulse shaper amplifier, simplified schematic.

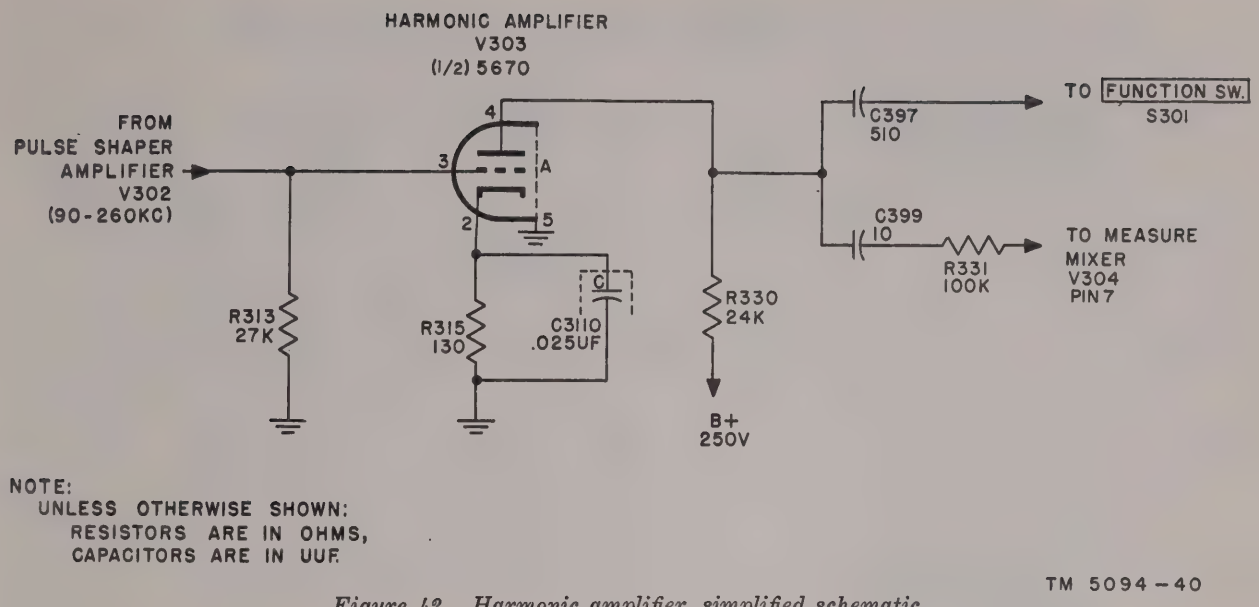


Figure 42. Harmonic amplifier, simplified schematic.

b. Additional amplitude compensation for the high harmonics is provided by the input network, which consists of capacitors C396 and C3145 and resistors R312 and R313 (fig. 41 and 42). This network has a rising amplitude response with frequency and tends to maintain a constant amplitude input regardless of the harmonic in use.

c. Tube V303A is a conventional amplifier stage. The output is developed across plate load resistor R330 and has two possible paths. One output is coupled through capacitor C397 to FUNCTION SW. S301. This output is used only in the CAL. position where a harmonic of 10 kc (9th to 26th) is fed to the oscilloscope to calibrate the interpolation oscillator. The other output is coupled through capacitor C399 and resistor R331 to the suppressor grid (pin 7) of V304, the measure mixer. Additional hf compensation is provided by the voltage divider action of C399, R331, and R314 (fig. 100).

58. Horizontal Deflection Amplifier
(figs. 43 and 100)

a. Horizontal deflection amplifier V504 is a paraphase push-pull amplifier which is directly coupled to the horizontal deflection plates of the cathode ray tube.

b. There are two possible inputs to this stage. In the MEAS. position of FUNCTION SW. S301, the input is the 15- to 20-kc signal coming from 15- to 20-kc amplifier V305. In this position, the 15- to 20-kc input from V305 is compared on the oscilloscope with the 15- to 20-kc signal from the interpolation oscillator.

c. In the CAL. position of FUNCTION SW. S301, the input is a selected harmonic of 10 kc (9th to 26th) coming from harmonic amplifier V303A. This input is used when calibrating the interpolation oscillator.

d. The input signal is applied across variable resistor R536 (HOR. GAIN). This control, located on the front panel, is used to compensate for changes in the input signal amplitude. To insure equal amplitudes of the push-pull output of V504A and V504B, the output of V504B, which is applied to V504A, is divided down by the two plate load resistors (R534 and R535). The signal taken from the junction of the two resistors is reduced by a factor equal to the gain of V504B. In this way, the amplitude of the signal applied to the grid of V504A is the same as the original signal amplitude at the grid of V504B. Resistor R529 is included in the plate circuit of V504A, in addition to plate load resistor R530, to equalize the gains of the push-pull amplifier.

e. Cathode bias is provided by resistors R531 and R533. Capacitor C507 couples the signal from V504B to the grid (pin 2) of V504A. The signal is developed across grid resistor R532.

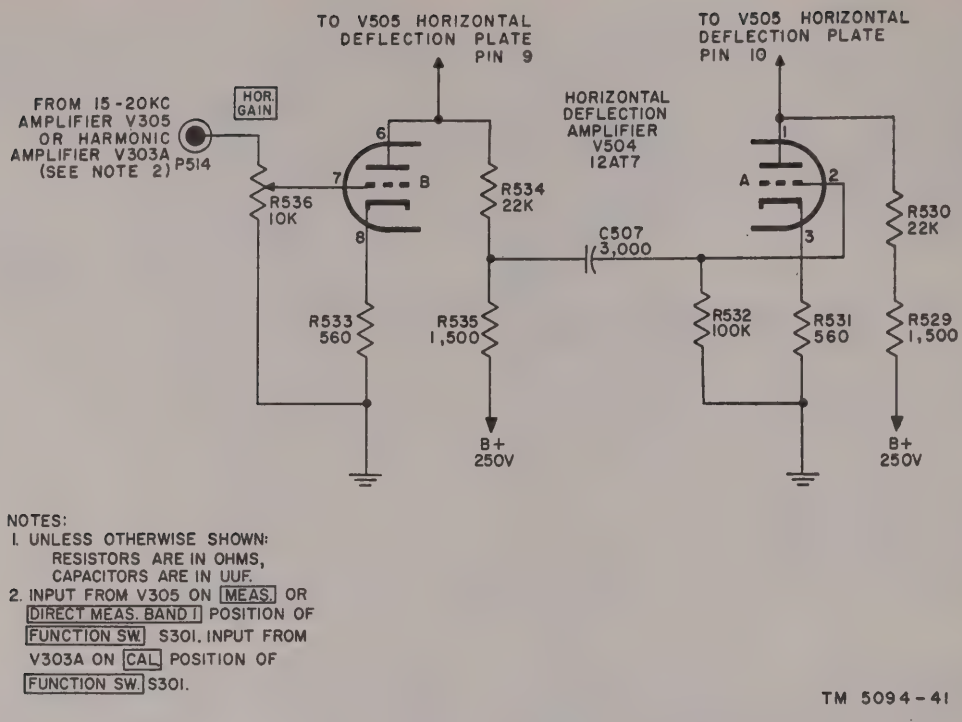


Figure 43. Horizontal deflection amplifier, simplified schematic.

59. Cathode-Ray Tube
(figs. 44 and 100)

Cathode-ray tube V505 is a type 2BP1. Signals from horizontal deflection amplifier V504 are directly coupled to the horizontal deflection plates (pins 9 and 10). Signals from vertical deflection amplifier V503 are directly coupled to the vertical deflection plates (pins 6 and 7). Direct coupling is possible because the high voltage for the oscilloscope (—750 volts) is applied to the cathode of V505. First anode (pin 8) voltage is applied through a voltage divider that consists of resistors R528 and R543. A voltage divider that includes the focus and intensity controls is operated from the —750-volt supply. This divider consists of R538, R527 (intensity control), R524, R526 (focus control), and R523. The main function of this divider circuit is to apply the proper potentials to the focus and intensity controls.

60. Vertical Deflection Amplifier
(figs. 45 and 100)

a. Vertical deflection amplifier V503 is similar to horizontal deflection amplifier V504, but it has greater gain because the highest frequency it must pass is only 20 kc. The input to this amplifier is the 15- to 20-kc output from the buffer amplifier of interpolation oscillator V402.

b. The input wave shape is not sinusoidal, but it resembles a sawtooth. Input coupling capacitor C505 is low in value (200$\mu\mu$f) so that the vertical amplifier response drops off at frequencies below 15 kc. Plate load re-

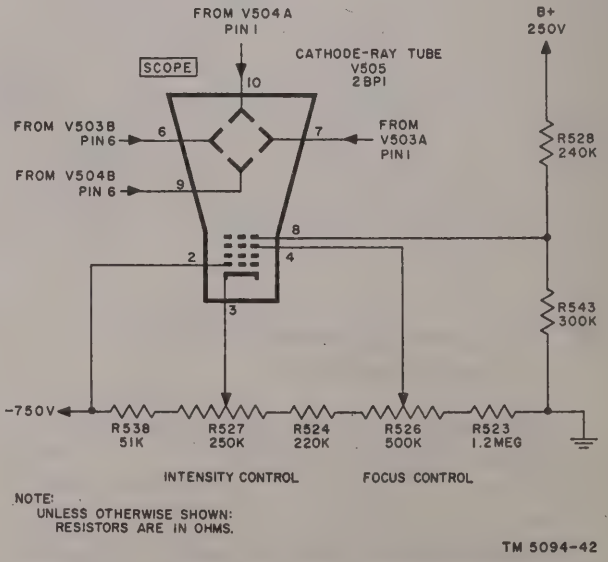


Figure 44. Cathode-ray tube, simplified schematic.

sistors R518, R519, R521, and R522 are proportioned so that the amplifier response drops off above 20 kc. The net result is to reduce the possibility of amplifying spurious responses and to improve the shape of the input signal for the production of Lissajous figures.

c. To insure equal amplitudes of the push-pull output of V503A and V503B, the output of V503A is divided by resistors R518 and R519. The signal is taken from the junction of the two resistors and is reduced by a factor of approximately 23, which is equal to the gain of V503A. This means that the amplitude of the signal applied to the grid V503B is the same as the original signal amplitude at the grid of V503A. Resistor R522 is included in the plate circuit of V503B to equalize the gains of V503A and V503B. Resistors R516 and R525 are grid return resistors. Resistors R517 and R520 furnish cathode bias.

61. Interpolation Oscillator

(figs. 46 and 100)

a. Interpolation oscillator V401 is a high-stability, variable-frequency oscillator with a range from 15 to 20 kc. It provides a means of determining interpolation frequencies for the DIRECT MEASURE or PROXY. OSC. dial to an accuracy of .001 percent. A tuned-grid oscillator, which is practically identical with the proxy oscillator except for the frequency range, is used. For a detailed discussion of this type of oscillator, refer to paragraph 63.

b. Variable capacitor C401 is used for tuning. A small tubular ceramic variable capacitor (C402, CAL. ADJ.) can be adjusted from the front panel to correct the calibration of the interpolation oscillator. After a 1-hour warm-up period, the oscillator drifts only about .5 cycle in the next 4 to 5 hours. This small drift is of no practical significance, particularly since the oscillator is calibrated before each use.

c. The output of the interpolation oscillator is taken from the untuned plate circuit. Because of the class C operation, the plate wave shape is nonsinusoidal and consists of a series of pulses that have narrow negative portions. These pulses are coupled through C404 to buffer amplifier V402.

d. Fixed capacitors C410, C411, C412, C414, and C415 determine the tuning range of the interpolation oscillator; the latter four capacitors also divide down the oscillator signal to be applied to the grid of V401. Capacitors C411 and C412 have negative temperature coefficients to improve the stability of the oscillator. Capacitor C410 is provided with one of three temperature coefficients, as determined

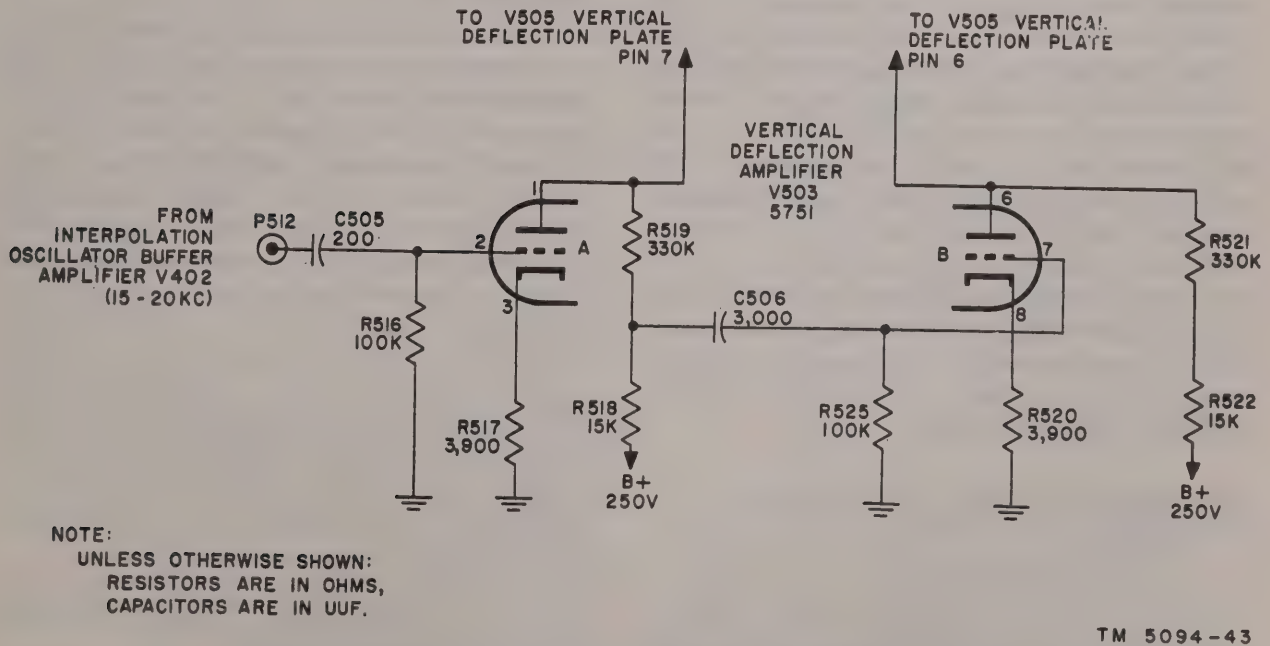


Figure 45. Vertical deflection amplifier, simplified schematic.

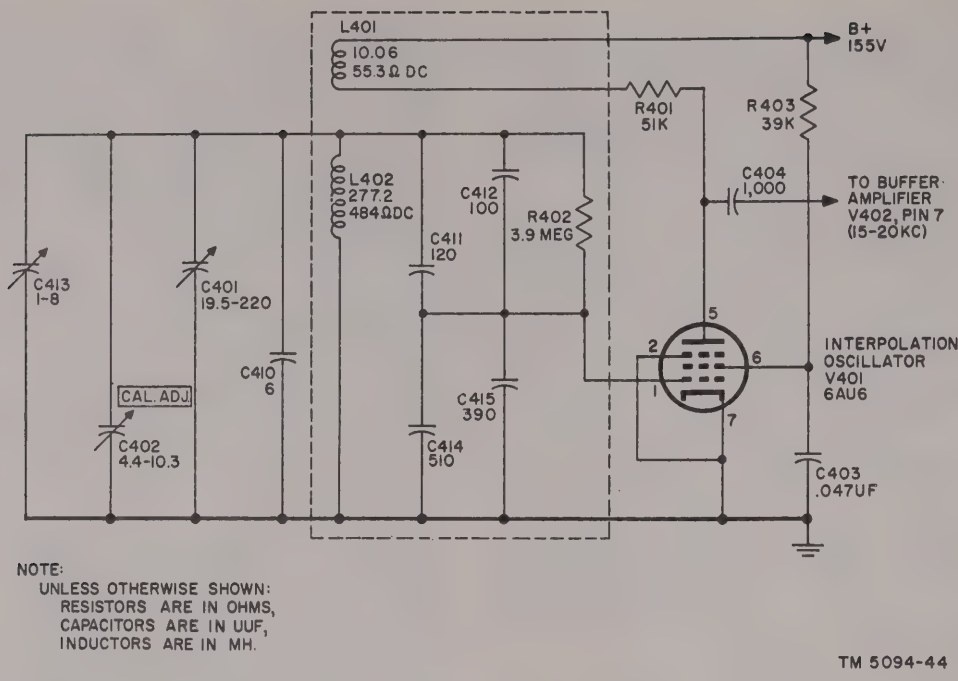


Figure 46. Interpolation oscillator, simplified schematic.

during initial alinement at the factory. The capacitor is rated at 6 μμf at a temperature of 25° C. Depending on the specific capacitor used, this capacitance will increase by approximately .0006 μμf or decrease by approximately .00198 μμf or .0045 μμf for each degree of rise in temperature, and will react in a similar but opposite manner to each degree of fall in temperature. Because the frequency meter is calibrated after C410 is installed, an exact duplicate of C410 must be used for replacement to insure the continued accuracy of the listings in the calibration book. The three variations of C410 can be distinguished by the type designation number printed on the capacitor (CC21AH060C, CC21SH060C, or CC21UJ060C).

e. Other V401 circuit elements include plate current phase angle correction resistor R401, screen dropping resistor R403, and screen grid bypass capacitor C403. Grid-leak bias is furnished by resistor R402.

62. Buffer Amplifier for Interpolation Oscillator

(figs. 47 and 100)

a. The first half of buffer amplifier V402 is cathode follower V402A. This is required to provide maximum isolation of the interpolation oscillator from the oscilloscope circuits. The input to the cathode follower is applied across a resistance voltage divider network that consists of resistors R404 and R405. The root mean square (rms) input voltage to the divider is approximately 80 volts and is reduced to approximately 4 volts by the divider.

b. The output of cathode follower V402A is developed across resistor R410. The wave shape at this point (pin 8) is unsuitable for the production of Lissajous figures on the oscilloscope. The output is coupled through capacitor C408 to an integrating circuit that consists of resistors R407 and R408 and capacitor C408. This integrating circuit changes the pulse wave shape to a sawtooth, which will produce a more satisfactory Lissajous figure. The integrating network reduces the rms amplitude of the wave to approximately .1 volt. The sawtooth voltage is amplified by V402B, developed across plate resistor R406, and coupled through capacitor C409 to jack J412. From here, the sawtooth voltage is applied to vertical deflection amplifier V503.

c. The plate (pin 6) of V402A is kept at rf ground by capacitor C407. Resistor R409 provides cathode bias for V402B.

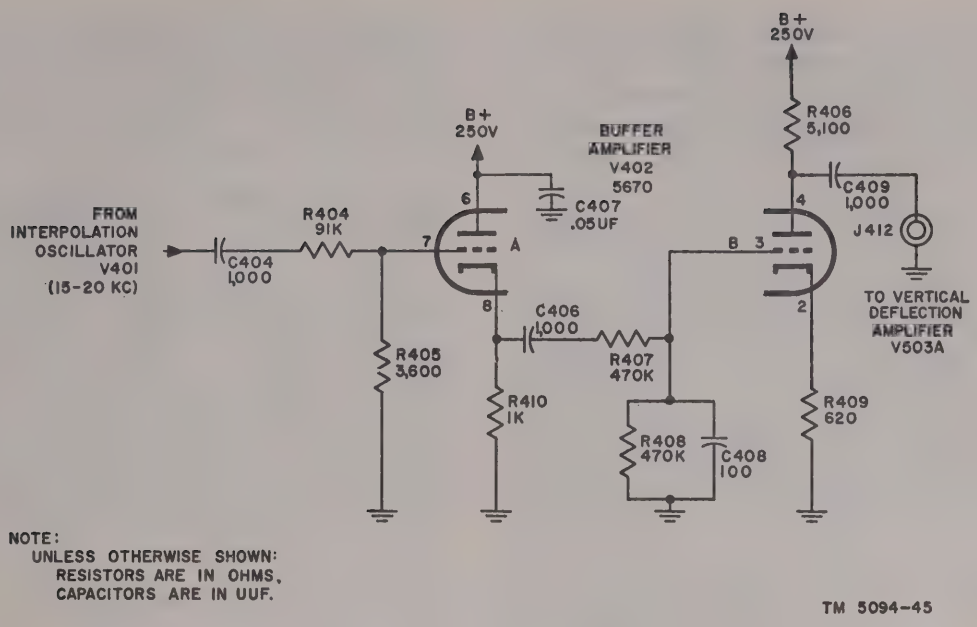


Figure 47. Buffer amplifier for interpolation oscillator, simplified schematic.

63. Proxy Oscillator

(figs. 48 and 100)

a. Proxy oscillator V101 is a modified tuned-grid oscillator with extremely good stability. The oscillator may be tuned over a frequency range of 97.5 to 256 kc, but is calibrated from 100 to 250 kc on the PROXY. OSC. dial. Trimmer capacitor C104 is used for calibrating the proxy oscillator. In a tuned-grid oscillator, oscillations in the grid-tank circuit are sustained by feedback energy coupled from the tickler (plate) winding of the oscillator coil to the grid winding. The feedback phase is controlled so that the feedback voltage appearing on the grid of V101 is in phase with the normal oscillator voltage.

b. Variations of tube input impedance normally have a considerable effect on oscillator stability. In the proxy oscillator, the effect of such variations is minimized by several expedients.

(1) The input impedance does not appear across the entire grid-tank circuit; it is effectively *tapped down* by the voltage-divider action of C102 and C108. The divider action is such that only about one-fourth of the total grid tank circuit voltage is applied to the grid of V101. Because the input impedance affects only one-fourth of the tank circuit impedance, the effect of the input impedance on frequency is reduced.

(2) Capacitor C108, which has a value of 200 $\mu\mu$f, is shunted across the grid-to-cathode interelectrode capacitance of V101. Because C108 is many times greater than the grid-to-cathode capacitance, it effectively *swamps out* changes in the interelectrode capacitance, and thus improves frequency stability.

(3) The use of a large value grid-leak resistor R102 (2.2 meg) also reduces input impedance effects on frequency. The high resistance value insures peak charging of capacitor C102 to produce a class C bias. With class C bias, the tube conducts grid current for only a small portion of a cycle, and thus minimizes grid current effects on frequency. Plate current also flows for a small portion of a cycle and reduces plate impedance effects on frequency.

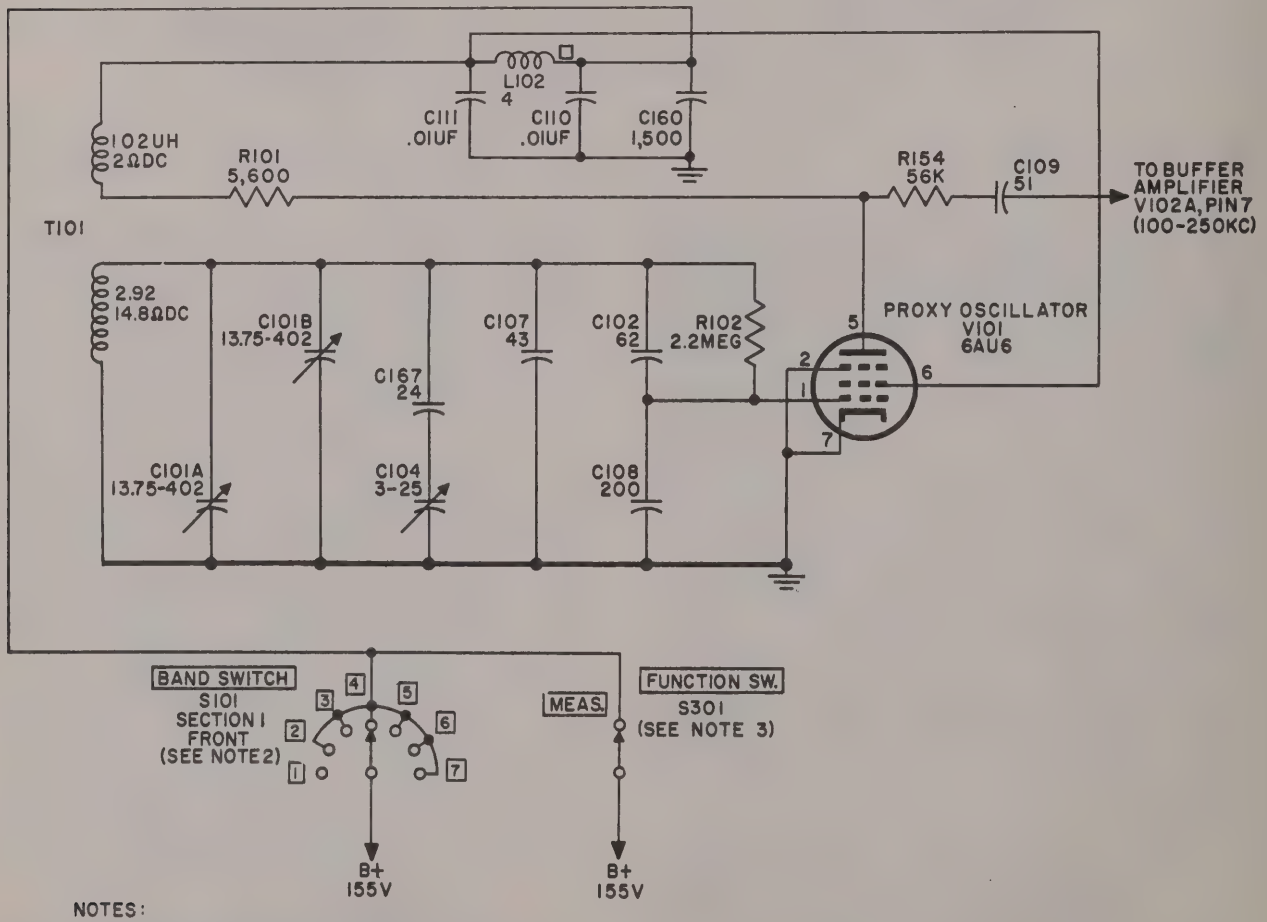
c. Variations of oscillator frequency caused by temperature changes are minimized by the use of low temperature coefficient components in the tank circuit, by careful mechanical construction, and by the use of negative temperature coefficient capacitors C102, C107, and C108.

d. Variations of supply voltages tend to change oscillator frequency. Plate and screen voltage variations are minimized by the use of a regulated power supply and by the decoupling filter, which consists of C111, L102, C160, and C110.

e. For an oscillator to operate at optimum stability, the tank circuit should operate as close to its natural resonant frequency as possible. Ordinarily, a tuned-grid oscillator operates below resonance as a result of improper phasing of the plate current. In the proxy oscillator, the plate current phase angle is corrected by series plate resistor R101. Additional phase correction is provided by capacitor C102 and resistor R102.

f. Loading effects on oscillator frequency are reduced by taking the oscillator output from the untuned plate circuit, by the isolating effects of capacitor C109 and resistor R154, and by the use of buffer stage V102. By connecting tuning capacitors C101A and C101B in parallel, a high LC ratio is established. This also tends to improve oscillator stability.

g. On bands 2 through 7 (fig. 48), the B-plus voltage for proxy oscillator V101 and buffer amplifier V102 is applied through BAND SWITCH S101, section 1 front. When S101 is set to BAND 1, this voltage is removed, but the circuit is not broken because the contacts of S101 are paralleled by contacts of FUNCTION SW. S301. When S301 is in the DIRECT



NOTES:
1. UNLESS OTHERWISE SHOWN:
   RESISTORS ARE IN OHMS,
   CAPACITORS ARE IN UUF,
   INDUCTORS ARE IN MH.
2. S101 SECTION I FRONT CONTACTS HERE IN BAND 2 THROUGH BAND 7 POSITONS.
3. S301 SECTION I CONTACTS HERE IN MEAS. POSITION ONLY.

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Figure 48. Proxy oscillator, simplified schematic.

MEAS. BAND 1 position, B plus is removed from the proxy oscillator and buffer amplifier. The unknown signal, instead of the proxy oscillator signal, is then applied to the measure mixer.

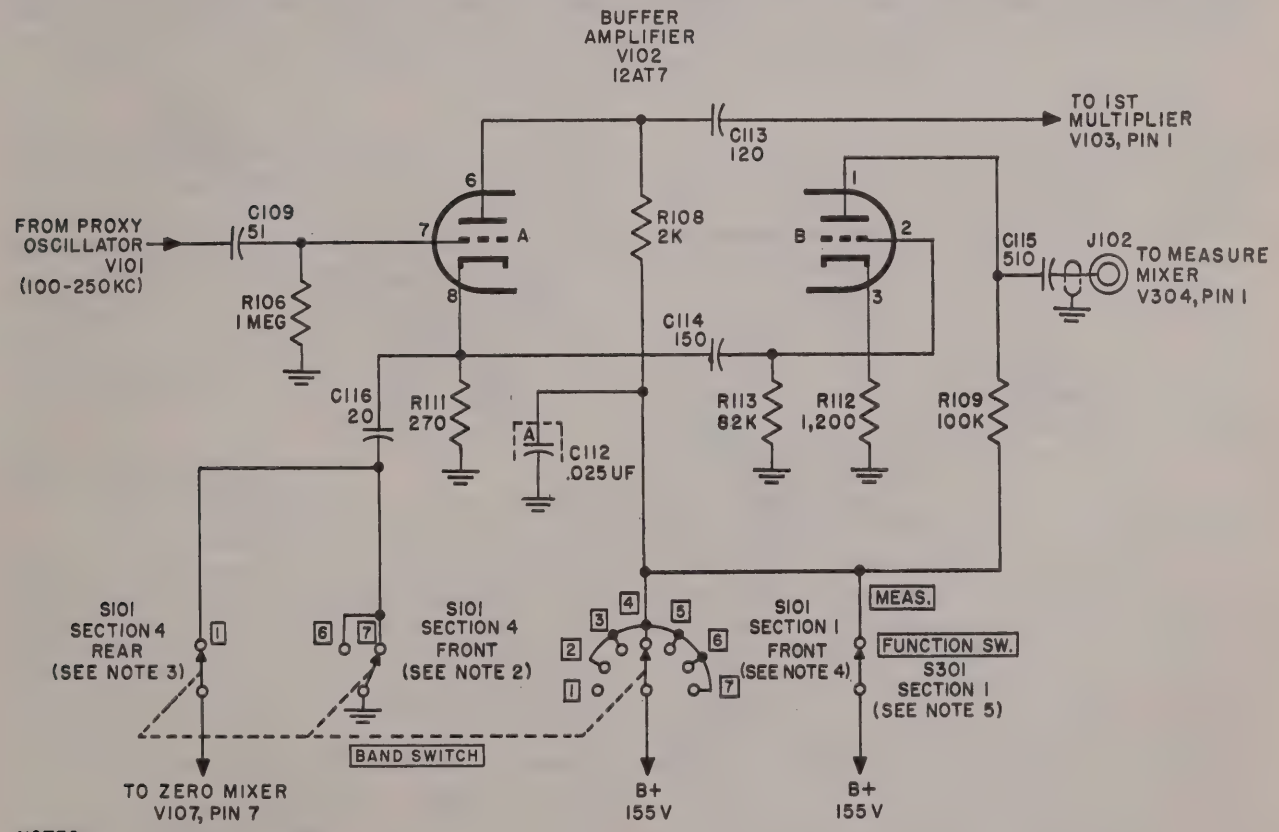
64. Buffer Amplifier for Proxy Oscillator

(figs. 48 and 100)

a. The output of the proxy oscillator is coupled through C109, developed across resistor R106, and applied to the grid (pin 7) of V102A, the first half of buffer amplifier V102. The function of the buffer amplifier is to isolate the proxy oscillator from load changes and thus improve its frequency stability.

b. Two outputs are taken from the cathode of V102A and one from the plate. The cathode outputs are developed across resistor R111. One output from the cathode (pin 8) is coupled through capacitor C116 and applied via BAND SWITCH S101, section 4 rear, to zero mixer V107 on band 1 when FUNCTION SW. S301 is set to MEAS. The second output from the cathode is coupled through capacitor C114 to the grid of V102B. The output from the plate (pin 6) of V102A is coupled through capacitor C113 to first multiplier V103.

c. The input to the second half of buffer amplifier V102B comes from the cathode (pin 8) of V102A and is developed across grid resistor R113. Tube V102B has one output taken from its plate (pin 1). This output is coupled through capacitor C115 and goes via jack J102 and plug P302 to measure mixer V304. The output is used on all bands and is heterodyned in the measure mixer with a selected harmonic of 10 kc to produce a difference frequency in the range of 15 to 20 kc.



NOTES:
1. UNLESS OTHERWISE SHOWN: RESISTORS ARE IN OHMS, CAPACITORS ARE IN UUF.
2. S101 SECTION 4 FRONT, CONTACTS HERE IN BAND 6 AND BAND 7 POSITIONS.
3. S101 SECTION 4 REAR, CONTACTS HERE IN BAND 1 POSITIONS ONLY.
4. S101 SECTION 1 FRONT, CONTACTS HERE IN BAND 2 THROUGH BAND 7 POSITIONS.
5. S301 SECTION 1, CONTACTS HERE IN MEAS. POSITION ONLY.

TM 5094-47

Figure 49. Buffer amplifier for proxy oscillator, simplified schematic.

65. First Multiplier

(figs. 50, 51 and 100)

a. The input to first multiplier V103 comes from the plate (pin 6) of the first half of buffer amplifier V102. This input (100 to 250 kc) is applied on bands 2 to 7. The cathode of V103 is grounded and the tube is grid leak biased by capacitor C113 and resistor R115.

b. One of three tank circuits may be connected to the plate of V103 by BAND SWITCH S101, section 2 front. These tank circuits are used as follows: BAND 2—L103 and C117 (.2 to .5 mc); BAND 3—L104 and C118 (.5 to 1.25 mc); BAND 4—L105, C119, and R146 (1 to 2.5 mc). On bands 4 through 7, the band 4 tank circuit remains connected. Variable capacitor C101C is connected to the plate of V103 at all times and is used to tune any of the three tank circuits as selected by the band switch. This variable capacitor is ganged to the PROXY. OSC. dial tuning capacitors and to the second and third multiplier and preselector tuning capacitors. Each coil of the three tank circuits is slug tuned and equipped with a trimmer capacitor for proper alinement and tracking. Capacitor C116 is in parallel with C101C and provides temperature compensation for frequency stability.

c. The band 4 tank circuit has a damping resistor (R146) inserted in series with the coil and trimmer capacitor. This resistor functions to reduce the output on the hf end of band 4, which would otherwise be excessive because of the high Q of coil L105. All unused coils in the frequency multipliers and the preselector are shorted out when not in use to prevent absorption of energy from the coils in use.

d. The output of V103 is coupled through capacitor C120 to a resistance voltage divider that consists of R124 and R125. The output of V103 is reduced to provide the desired am-

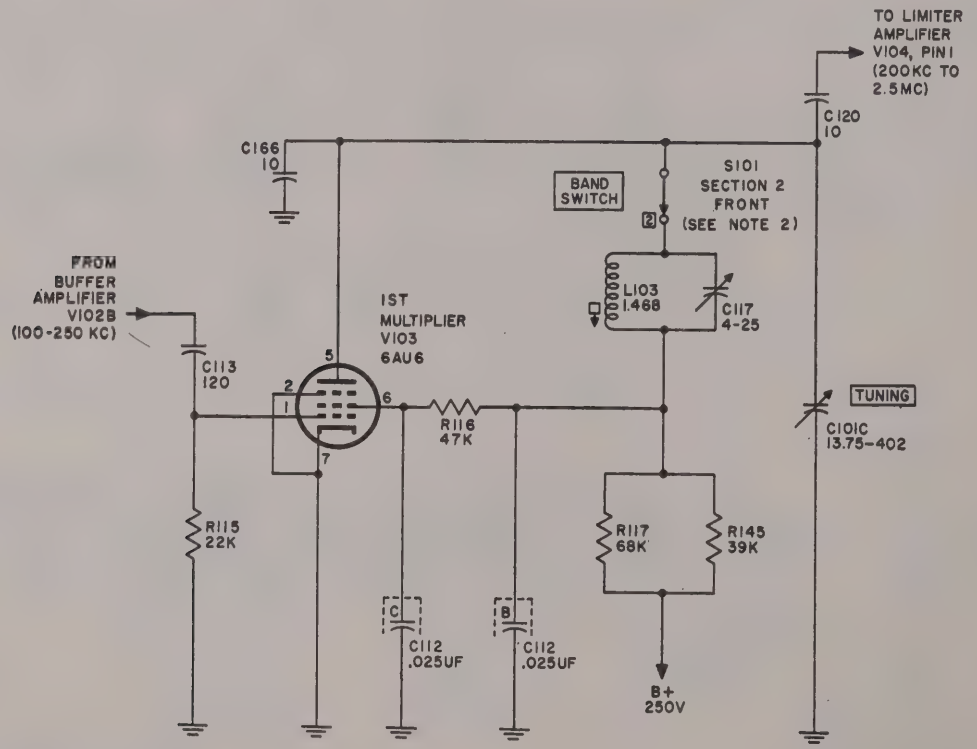


Figure 50. First multiplier, simplified schematic.

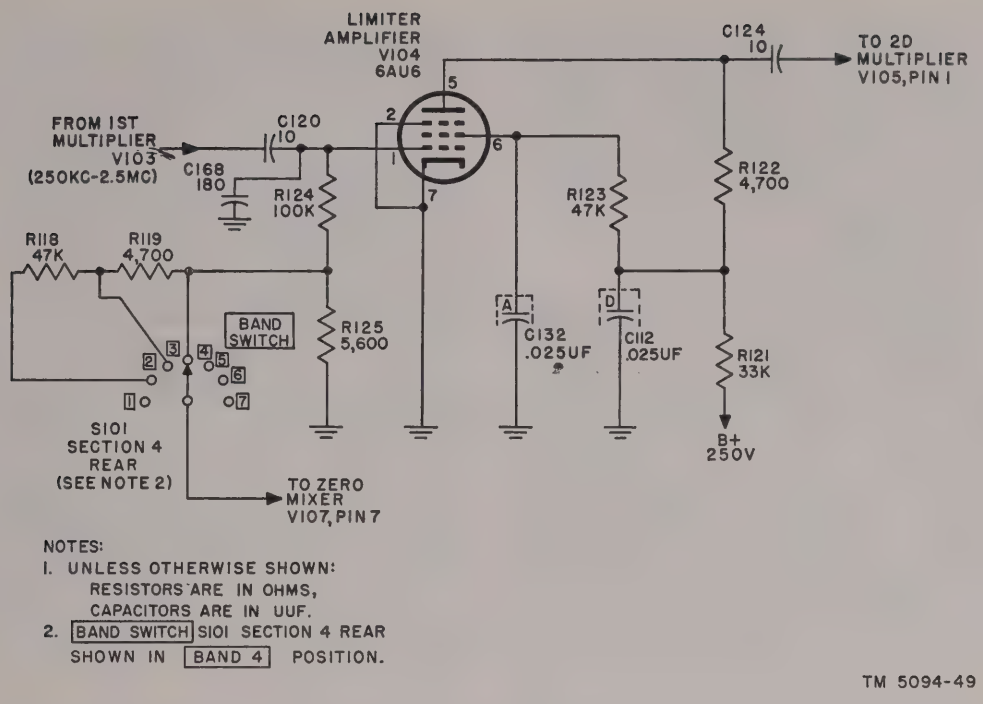


Figure 51. Limiter-amplifier, simplified schematic.

plitude necessary to drive zero mixer V107. Resistors R118 and R119 function to correct the output of V103 on bands 2 and 3. The output of V103 is applied to the zero mixer via BAND SWITCH S101, section 4 rear.

e. Resistors R117 and R154 and capacitor C112B comprise a plate decoupling network. The screen dropping resistor is R116. Capacitor C112C bypasses the screen grid.

66. Limiter-Amplifier

(figs. 51 and 100)

a. Limiter-amplifier V104 is placed between the first and second frequency multipliers to reduce the development of spurious signals which may be caused by the frequency multipliers. This stage has an input from the first frequency multipliers on bands 2 through 7, but is effective only on bands 5 through 7.

b. The output of the usual type of frequency multiplier is a damped wave having an envelope that contains the frequency of the fundamental (input) wave. The effect of this component of fundamental frequency is to produce spurious frequencies on either side of the desired frequency spaced by the amount of the fundamental frequency. As an example, consider that the fundamental (proxy oscillator) frequency is 225 kc and is multiplied 40 times on band 6, producing a multiplied output of 9 mc. Because of the damped wave envelope, spurious frequencies are produced at 8.775 mc and 9.225 mc. If present, such spurious frequencies make it difficult to select the right setting on the PROXY. OSC. dial. The limiter-amplifier functions to prevent such spurious responses by removing the envelope of the damped wave train and producing an output in which individual cycles are of equal amplitudes.

c. The limiter-amplifier uses grid-leak bias provided by capacitor C120 and resistors R124 and R125. Because of this bias, negative portions of the input wave are clipped when the stage is driven to cutoff. Limiting action is improved by the use of high-Q coils in the first multiplier to reduce the rate of pulse amplitude decay. Positive limiting is accomplished in V104 by grid limiting and overdriving the stage with high amplitude input signals. As a result of the limiting effect, the effective grid signal for V105 is a wave train that has cycles of substantially equal amplitude and, therefore, contains little or no component of the fundamental frequency.

d. The output of V104 is developed across

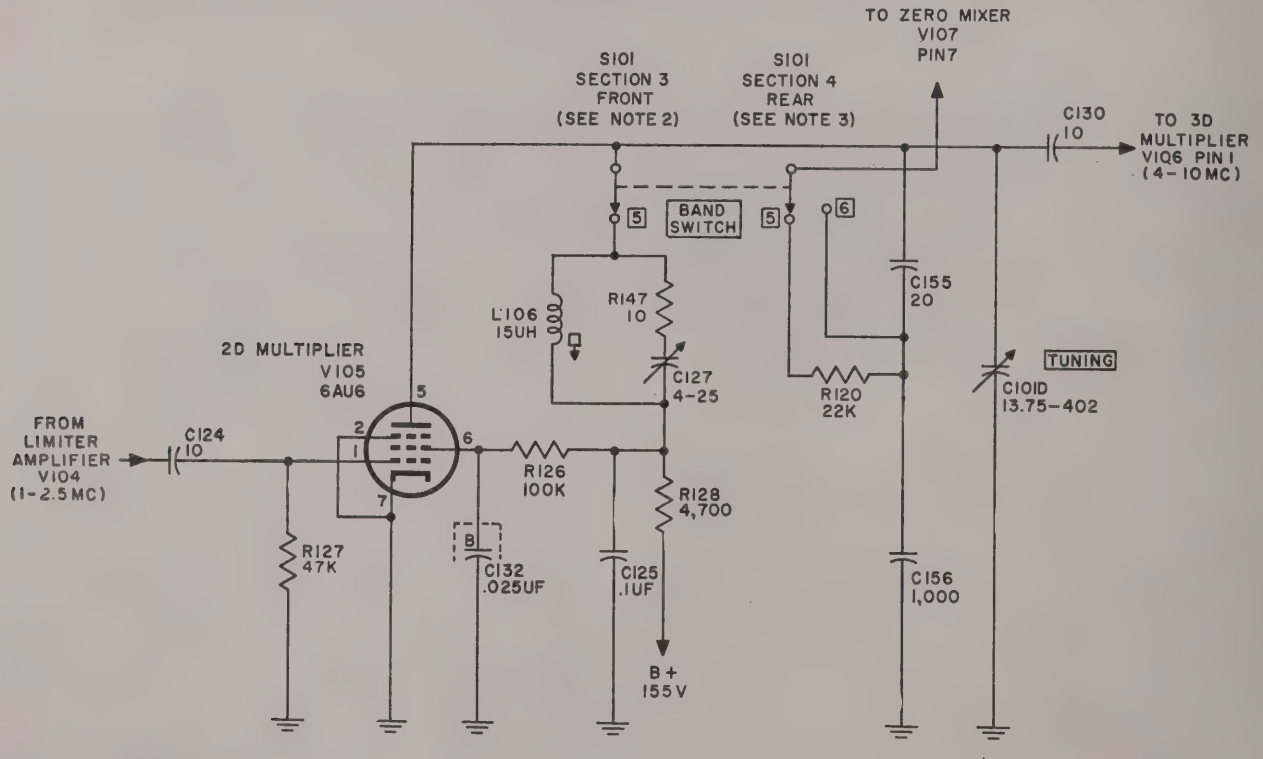
resistor R122 and coupled through C124 to second multiplier V105. The plate decoupling network consists of resistor R121 and capacitor C112D. Screen voltage is dropped by resistor R123. Capacitor C132A is used to bypass the screen grid.

67. Second Multiplier

(figs. 52 and 100)

a. Second multiplier V105 operates similarly to the first multiplier except for the frequencies involved. The input to V105 comes from the limiter-amplifier and is developed across grid return resistor R127. The input frequency is the proxy oscillator frequency multiplied by a factor of 10 (1 to 2.5 mc) by the action of the first frequency multiplier. The input frequency is multiplied by two on band 5 (2.5 to 4 mc) and by four on band 6 (5 to 10 mc). The band 5 tank circuit consists of coil L106, trimmer capacitor C127, and damping resistor R147. The band 6 tank circuit consists of coil L107, trimmer capacitor C128, and damping resistor R148. Each tank circuit is tuned by capacitor C101D when connected into the circuit by the BAND SWITCH.

b. As shown by the connections to BAND SWITCH S101, section 3 front, V105 functions only on bands 5, 6, and 7 (fig. 100). On all other positions, plate voltage is removed. The output of the second multiplier is fed to two stages. It is coupled through capacitor C130 to third multiplier V106. The other output is taken from the junction of a capacitive voltage divider that consists of capacitors C155 and C156. Voltage division is used here for the same reason as explained for the first frequency multiplier. A capacitive rather than a resistive voltage divider is used in this instance because for the high frequencies involved



NOTES:
1. UNLESS OTHERWISE SHOWN: RESISTORS ARE IN OHMS, CAPACITOR ARE IN UUF, INDUCTORS ARE IN MH.
2. S101, SECTION 3 FRONT, SHOWN IN BAND 5 (2.5-5 MC) POSITION. THIS STAGE ALSO SWITCHES TO BAND 6 (5-10 MC) POSITION (NOT SHOWN).
3. S101, SECTION 4 REAR, SHOWN IN BAND 5 (2.5-5 MC) POSITION.

TM 5094-50

Figure 52. Second multiplier, simplified schematic.

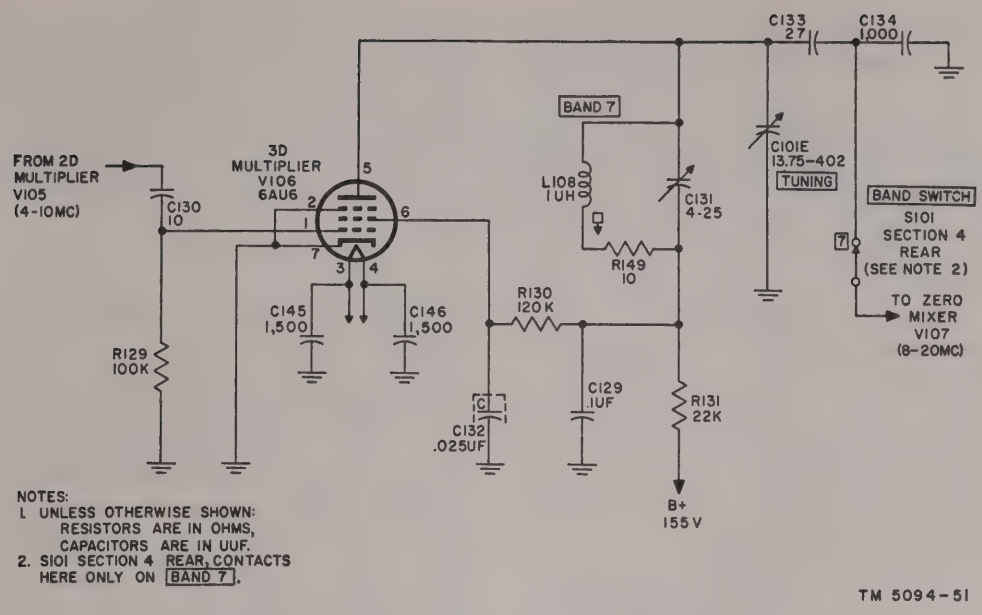


Figure 53. Third multiplier, simplified schematic.

(2.5 to 10 mc), the inherent capacitance of resistors tends to make their voltage division unpredictable. The output from the capacitive voltage divider is applied to the zero mixer through switch S101, section 4 rear. Resistor R120 further reduces the output on band 5 to a value suitable for the operation of the zero mixer. Capacitor C155 has a negative temperature coefficient. This serves to improve the stability of the tank circuits used on bands 5 and 6.

68. Third Multiplier
(figs. 53 and 100)

a. Third multiplier V106 is similar to the other two multipliers but uses only one plate tank coil and so requires no switching in the plate circuit. The plate tank circuit consists of coil L108, trimmer capacitor C131, and damping resistor R149.

b. The tank circuit is tuned by variable capacitor C101E. It is used only when the BAND SWITCH is on BAND 7 (8 to 20 mc) and provides a multiplication factor of 2. Since the input to V106 is at a multiplication factor of 40, the output of the third multiplier has an output equal to 80 times the proxy oscillator frequency. Capacitor C133 has a negative temperature coefficient to improve the frequency stability of the plate tank circuit. The output of V106 is taken from a capacitive voltage divider that consists of C133 and C134. This output (on band 7) is fed to zero mixer V107, via BAND SWITCH S101, section 4 rear.

c. Plate decoupling is provided by resistor R131 and capacitor C129. The screen bypass capacitor is C132C and the screen dropping resistor is R130. Resistor R129 provides grid-leak bias for V106.

69. Audio Amplifier and Bucking Amplifier
(figs. 54 and 100)

a. The input signal to audio amplifier V501A is an audible beat frequency signal coming from zero mixer V107. The signal is applied through plug P504 and developed across grid resistor R501. The large value of R501 (10 meg) provides a contact bias in the order of 1 volt. This is the only bias applied to the grid of the audio amplifier. The audio amplifier operates in conjunction with bucking amplifier V501B to provide audio volume expansion. The volume expansion feature is provided to reduce the effect of spurious responses. The audio output is very low on spurious (low amplitude) responses, but increases greatly on the desired response.

b. The principle of operation of expansion is as follows. The audio (beat frequency) input is applied to the grid (pin 2) of audio amplifier V501A. There are three outputs from this amplifier. One is a low level output tapped

off at the junction of plate load resistors R502 and R503. This output is coupled through capacitor C501 to the grid (pin 7) of bucking (expansion) amplifier V501B. The audio and bucking amplifiers are connected to opposite ends of a voltage divider which consists of R504, R505, and R506. The two signals fed to the voltage divider are 180° out of phase and are controlled in amplitude so that they cancel each other at the center of R505. With a weak input signal (spurious response) to audio amplifier V501A, variable resistor R505 is adjusted for a minimum output in the headphones. When the desired (strong) response is applied, the bucking amplifier is cut off and the audio amplifier functions normally to provide an expanded (volume) output.

c. To cut off bucking amplifier V501B on the desired response, the high level output of the audio amplifier is rectified and the resultant bias is applied to the grid (pin 7). Rectification actually occurs in the grid-to-cathode circuit of blinker amplifier V502A, and thus charges capacitor C502. The bias is applied through grid resistors R508 and R509 to the grid of the bucking amplifier.

d. The system is designed so that expansion occurs at input signal levels just above the expected spurious response amplitudes. As a result of the audio expansion and other design features described elsewhere, all spurious responses are down 30 db or more. This makes it very unlikely that a spurious response will be mistaken for the desired one.

70. Blinker Amplifier

(figs. 55 and 100)

a. Blinker amplifier V502A and BLINKER neon lamp I 501 provide a visual method of detecting very low frequency beat signals which may be difficult to hear in the headset.

b. In the absence of an input signal, blinker amplifier V502A is cut off by fixed bias. This bias originates in the 155-volt supply and is reduced to approximately 7.4 volts by a voltage divider which consists of resistors R511 and R512. When a signal is applied to the grid, additional bias is developed by grid rectification of the input signal. (This bias also is used to control bucking amplifier V501B.) Input signals to the blinker amplifier are coupled from audio amplifier V501A through capacitor C502 and are developed across grid resistor R510. When an input signal is present, the positive portion of the signal drives the blinker amplifier into conduction, and thus causes the

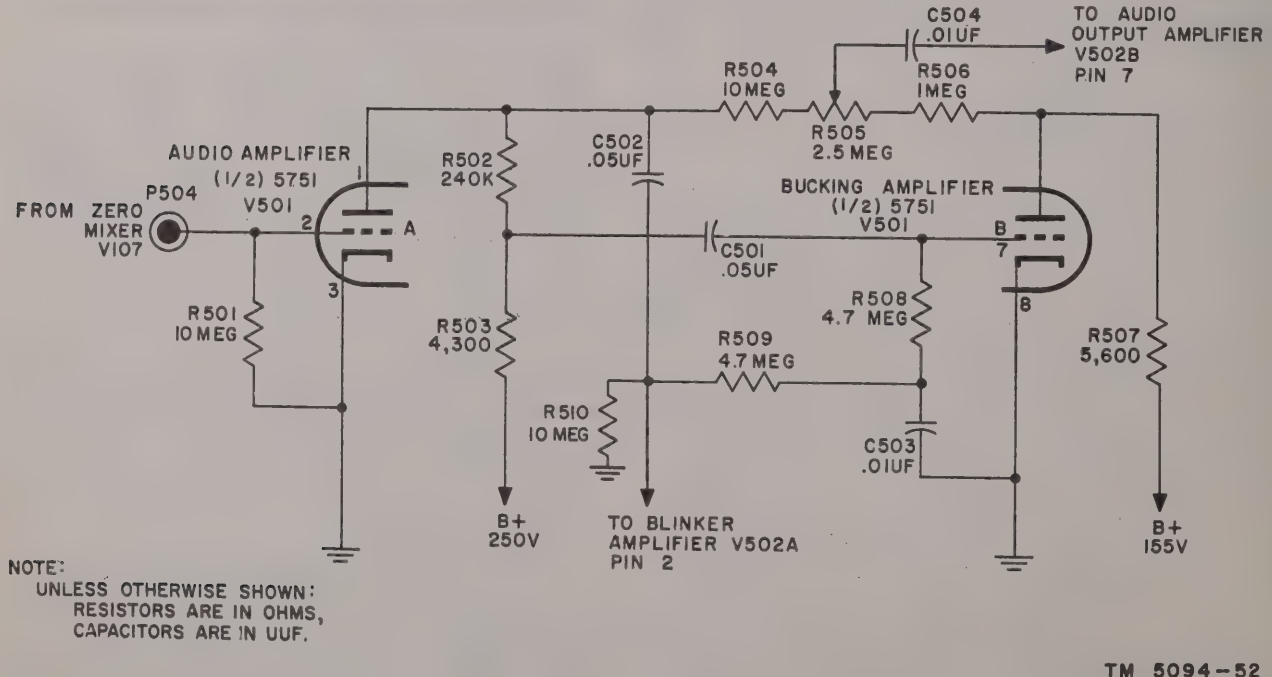


Figure 54. Audio amplifier and bucking amplifier, simplified schematic.

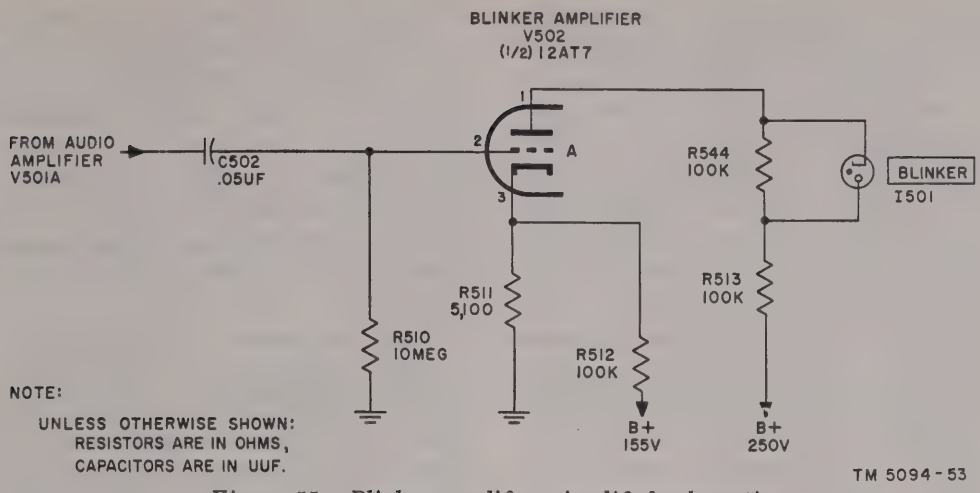


Figure 55. Blinker amplifier, simplified schematic.

neon bulb to fire at the repetition rate of the input frequency. Resistor R544, across the neon bulb, develops the ionization potential during conduction cycles. The plate lead of V502A is shielded to prevent spurious oscillation. Resistor R513 is a current limiting resistor.

71. Audio Output Amplifier
(figs. 56 and 100)

Audio output amplifier V502B is a conventional power output stage which is used to drive the headset. Cathode bias is provided by resistor R515. The output of V502B is applied through transformer T501 to terminal 8 of chassis connector jack J515. From here it is applied to PHONES jack J310, located on the harmonic selector subchassis.

72. Power Supply
(fig. 99)

a. The power supply outputs are as follows: +155 volts regulated, +250 volts unregulated, —750 volts unregulated, and three filament voltage outputs. An interlock system is provided so that disconnecting any subchassis plug (except the interpolation oscillator plug) removes all dc supply voltages from the remaining subchassis. This is accomplished by connecting the center tap of plate transformer T601 through a series connection to all subchassis plugs (except the interpolation oscillator plug) to ground.

b. An electronically regulated +155-volt output is provided to improve the stability of the circuits in the frequency meter. The regulator has an input of 250 volts, which is full-wave

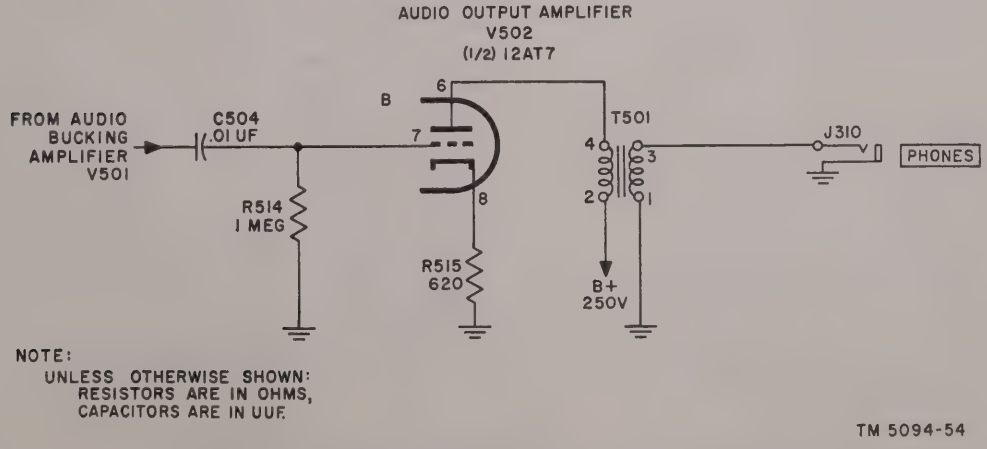


Figure 56. Audio output amplifier, simplified schematic.

rectified by tube V603 and filtered by a choke-input filter which consists of choke coils L601A and L601B and capacitors C601 and C602. A series-type regulator is used with tube V602, which acts as the series element. The operation of the regulator is as follows: the control grid (pin 5) of V602 is held at +150 volts at all times by the action of gas regulator tube V601, and the cathode (pin 8) impedance of V602 is an equivalent resistance which consists of the load of all circuits using the regulated output. Regulator tube V602 acts as a cathode follower and the cathode voltage (regulated output) under average line conditions is 155 volts. This establishes a 5-volt bias for V602. If the line voltage rises, the control grid voltage of V602 is maintained at its original value of 150 volts by V601. However, the plate voltage of V602 rises and the cathode voltage tends to follow because of the increased plate current. The increase in cathode voltage increases the bias and the plate resistance of V602. Most of the rise in plate voltage is dropped across the increased plate resistance and the cathode voltage tends to remain constant. The regulation is such that a 10 percent change of input voltage at any one supply line frequency will not produce more than a change of ±4.5 volts in the regulated output. Capacitor C603 in the cathode circuit of V602 provides additional filtering and improves the regulation of the supply. Resistors R601 and R602 limit the current of V601.

c. The —750-volt output is obtained by rectifying the ac voltage which appears across terminals 5 and 7 of transformer T601 by a multiple section selenium rectifier (CR601). This negative voltage is filtered by capacitor C604. A negative high-voltage supply is used for cathode-ray tube V505 because it facilitates the use of direct-coupled deflection amplifiers.

d. Transformer T602 has three filament voltage outputs. From terminals 5 and 6, a 5.1-volt output goes to rectifier tube V603. A 6.5-volt output from terminals 7 and 8 supplies filament power for the cathode-ray tube. The two windings of terminals 9 and 10, and 11 and 12 are connected in series to supply 6.5 volts to all the remaining filaments. Transformers T601 and T602 each have double primary windings. This provides for operation on either 115 or 230 volts, depending on the position of switch S602. The switch places the two primary windings for each transformer in parallel for 115-volt operation and in series for 230-volt operation. S602 is normally in the 115-volt position when shipped from the factory. Switch S601 is the POWER switch. Two 2-ampere fuses, (F601 and F602) are provided to protect the equipment against overloads. Two spare nonoperating fuses are contained in SPARE FUSE holders on the front panel.

CHAPTER 5.

FIELD MAINTENANCE

Note. This chapter contains information for field maintenance. The amount of repair that can be performed by units having field maintenance responsibility is limited only by the tools and test equipment available and by the skill of the repairman.

Section I. TROUBLESHOOTING AT FIELD MAINTENANCE LEVEL

Warning: Certain points located throughout the chassis of the frequency meter are at potentials of 750 volts with respect to chassis ground. Do not touch these points while power is applied to the frequency meter. Be very careful when handling or testing any part of the frequency meter while it is connected to the power source.

73. Troubleshooting Procedures

a. General. The first step in servicing a defective frequency meter is to sectionalize the fault. Sectionalization means tracing the fault to a major component or circuit responsible for the abnormal operation of the frequency meter. The second step is to localize the fault. Localization means tracing the fault to the defective part responsible for the abnormal condition. Some faults, such as burned-out resistors, arcing, and shorted transformers often can be located by sight, smell, and hearing. The majority of faults, however, must be localized by checking voltages and resistances or by signal substitution.

b. Component Sectionalization and Localization. Listed below is a group of tests arranged to simplify and reduce unnecessary work and aid in tracing a trouble to a specific component. The simple tests are used first. Those that follow are more complex. Follow the procedure in the sequence. A serviceman must be careful to cause no further damage to the frequency meter while it is being serviced. In general, the trouble is traced to a section of the frequency meter, and the faulty component in that section is located; then the trouble is remedied. The service procedure is summarized as follows.

(1) *Visual inspection.* The purpose of visual inspection is to locate any visible trouble. Through inspection alone, the repairman frequently may discover the trouble or determine the circuit in which the trouble exists. This inspection is valuable in avoiding additional damage to the frequency meter which might occur through improper servicing methods, and in forestalling future failures.

(2) *Operational test.* The operational test (par. 38) is important because it frequently indicates the general location of trouble. In many instances, the information gained will determine the exact nature of the fault. To utilize this information fully, all symptoms must be interpreted in relation to one another.

(3) *Troubleshooting chart.* The trouble symptoms listed in this chart (par. 77) will aid greatly in localizing trouble.

(4) *Signal substitution.* If the proper signal generators are available, signal substitution is effective in localizing trouble on this equipment (pars. 79 and 80).

(5) *Intermittents.* In all these tests, the possibility of intermittent conditions should not be overlooked. If present, this type of trouble often may be made to appear by tapping or jarring the equipment. It is possible that some external connection may cause the trouble. Test the wiring for loose connections and move the components with an insulated tool such as a fiber rod. This may show where a faulty connection or component is located.

74. Troubleshooting Data

Caution: Always check the circuit labels, because the schematic diagram in the manual may not include circuit changes made during equipment production. Take advantage of the material supplied in this manual. It will help in the rapid location of fault. Consult the following troubleshooting data.

Fig.	Par.	Title
57		Proxy oscillator-multiplier subchassis, component location, top view.
58		Proxy oscillator-multiplier subchassis, with gang capacitor shield removed and terminal cover tilted, component location, top view.
59		Proxy oscillator-multiplier subchassis, component location, bottom view.
77		Proxy oscillator-multiplier subchassis, voltage and resistance data.
78		Proxy oscillator-multiplier subchassis, terminal board, voltage and resistance data.
94		Proxy oscillator-multiplier subchassis, schematic diagram.
60		Crystal oscillator-divider subchassis, component location, top view.
61		Crystal oscillator-divider subchassis, component location, left bottom view.
62		Crystal oscillator-divider subchassis, component location, right bottom view.
79		Crystal oscillator-divider subchassis, voltage and resistance data.
80		Crystal oscillator-divider subchassis, terminal board, voltage and resistance data.
95		Crystal oscillator-divider subchassis, schematic diagram.
63		Harmonic selector subchassis, component location, top view.
64		Harmonic selector subchassis, component location, bottom view.
65		Harmonic selector subchassis, terminal board cover laid back, component location, bottom view.
75		Terminal board TB3103, component location.
81		Harmonic selector subchassis, voltage and resistance data.
82		Harmonic selector subchassis, terminal board, voltage and resistance data.
96		Harmonic selector subchassis, schematic diagram.
66		Interpolation oscillator subchassis, component location, top view.
67		Interpolation oscillator subchassis, cover removed, component location, top view.
68		Interpolation oscillator subchassis, component location, bottom view.
83		Interpolation oscillator subchassis, voltage and resistance data.
84		Interpolation oscillator subchassis, terminal board, voltage and resistance data.
97		Interpolation oscillator subchassis, schematic diagram.
69		Indicator subchassis, component location, top view.
70		Indicator subchassis, component location, left bottom view.
71		Indicator subchassis, component location, right bottom view.
85		Indicator subchassis, voltage and resistance data.
86		Indicator subchassis, terminal board, voltage and resistance data.
98		Indicator subchassis, schematic diagram.
72		Power supply subchassis, component location, top view.
73		Power supply subchassis, component location, bottom view.
87		Power supply subchassis, voltage and resistance data.
88		Power supply subchassis, terminal board, voltage and resistance data.
99		Power supply subchassis, schematic diagram.
74		Junction box, component location.
89		Junction box, voltage and resistance data.
78		Dc resistance of transformers and coils.

75. Test Equipment Required for Troubleshooting

The items of test equipment required for troubleshooting Frequency Meter FR–4/U are listed below. Technical manuals associated with each item are also listed.

Test equipment	Technical manual
Audio Oscillator TS–382A/U	TM 11–2684A
Oscilloscope OS–8A/U	TM 11–1214
RF Signal Generator AN/URM–25B	TM 11–5551B
Electron Tube Test Set TV–2/U	TM 11–2661
Multimeter TS–352/U	TM 11–5527
Electronic Multimeter TS–505/U	TM 11–5511
Radio Receiver R–395/PRD–1	TM 11–677

76. General Precautions

Observe the following precautions very carefully when servicing the frequency meter.

a. Be careful when the dust cover is removed from the frequency meter; dangerous voltages are present.

b. If the frequency meter has been operating for some time, use a cloth when removing the metal tube shields, and use a tube puller to remove the tubes to prevent burning the hands or fingers.

c. When servicing the interpolation oscillator subchassis, do not remove the shield cover unless it is absolutely necessary. If any interpolation oscillator components are replaced, the

interpolation oscillator will have to be recalibrated (par. 87).

d. Be careful not to bend variable capacitor plates. This could cause a short circuit or a change of alinement.

e. Do not overtighten screws when assembling mechanical couplings.

f. When changing a component that is held by screws, always replace the lockwashers.

g. Careless replacement of parts often makes new faults inevitable. Note the following points:

(1) Before a part is unsoldered, note the position of the leads. If the part, such as a power transformer, has a number of connections, tag each lead.

(2) Be careful not to damage other leads or parts by pushing or pulling them out of the way.

(3) Do not use a large soldering iron when soldering small resistors or ceramic capacitors. Overheating of the small parts may ruin or change the value of the component.

(4) Do not allow drops of solder to fall into parts of the chassis, because they may cause short circuits.

(5) A carelessly soldered connection may create new faults. A poorly soldered joint is one of the most difficult faults to find; therefore, it is very important to make well-soldered joints.

(6) When a part is replaced in a high-frequency (hf) circuit, it must be placed in the exact position occupied by the original part. A part that has the same electrical value but different physical size may cause trouble in hf circuits. Give particular attention to proper grounding when replacing a part; use the same ground which was used in the original wiring. Failure to observe these precautions may result in improper operation.

(7) *Do not disturb* any of the alinement adjustments unless it definitely has been determined that the trouble is caused by an adjustment which is improperly set.

77. Troubleshooting Chart

The following chart is supplied as an aid in locating trouble in the frequency meter. It lists the symptoms which the repairman observes, either visually or aurally, while making a few simple tests. The chart also indicates how to localize trouble quickly to the various subchassis and to certain stages or sections within the particular subchassis. After the trouble has been localized to a stage or circuit, a tube check and voltage and resistance measurements of this stage or circuit should be sufficient to isolate the defective parts. Normal voltage and resistance readings are given in figures 77 through 89. The following is a list of subchassis and their respective symbol block assignments, to aid in the identification of the subchassis upon which a component is installed.

Proxy oscillator-multiplier subchassis, 100 to 199
Crystal oscillator-divider subchassis, 200 to 299
Harmonic selector subchassis, 300 to 399, 3100 to 3199
Interpolation oscillator subchassis, 400 to 499
Indicator subchassis, 500 to 599
Power supply subchassis, 600 to 699
Junction box, 700 to 799

Symptom	Probable trouble	Correction
1. POWER switch in ON position. Dial lamp does not light; oscilloscope face does not light up; no hum can be heard in headset.	Blown fuse F601 or F602	Replace fuse with spare.
2. Fuse F601 or F602 blows when POWER switch is moved to ON position.	Shorted filter capacitor	Check capacitors C601, C602, C603, and C604. Replace if necessary.
	Defective rectifier tube	Check V603 and replace if necessary.
	Defective selenium rectifier	Check CR601 and replace if necessary.
	Line voltage switch S602 in wrong position.	Reset switch S602 to proper position.

Symptom	Probable trouble	Correction
3. OVEN HEATER lamp I 201 on crystal oscillator chassis does not glow with medium intensity when POWER switch is set to ON.	Defective fine and/or coarse thermostats or heaters in crystal oven HR201.	Check thermostats and heaters. Replace if necessary.
	Defective lamp	Check I 201 and replace if necessary.
4. OVEN HEATER lamp I 201 does not begin to cycle from dim to off after a few minutes of warmup time.	Defective thermostat (fine or coarse).	Check thermostat and replace if necessary.
5. No brightness in cathode-ray tube, but dial light is on.	Defective cathode-ray tube	Replace V505.
	No high voltage	Check CR601 and C604. Replace if required.
	Improper element voltages on V505	Check bleeder consisting of R523, R526, R524, R527, and R538. Also check R528 and R543. Replace defective part.
6. No vertical trace on cathode-ray tube, but horizontal trace appears.	Defective interpolation oscillator tube or associated components.	Check V401 and components. Replace defective part.
	Defective buffer tube V402 or associated components.	Check V402 and components. Replace defective part.
	Defective vertical deflection amplifier tube V503 or associated components.	Check V503 and components. Replace defective part.
7. Horizontal deflection on SCOPE in CAL. position of FUNCTION SW., but not in MEAS. position.	Defective mixer tube V304 or associated components.	Check V304 and components. Replace defective parts.
	Defective 15–20 kc amplifier tube V305 or associated components.	Check V305 and components. Replace defective part.
	Defective proxy oscillator tube V101 or associated components.	Check V101 and components. Replace defective part.
	Defective buffer-amplifier tube V102 or associated components.	Check V102 and components. Replace defective part.
8. Horizontal deflection on SCOPE in CAL. and MEAS. positions of FUNCTION SW., but none in DIRECT MEAS. BAND 1 position.	Defective rf gate amplifier tube V303B or associated components.	Check V303B and components. Replace defective part.
9. No horizontal deflection on SCOPE in any position of FUNCTION SW.	Defective indicator, harmonic selector, or crystal oscillator-divider subchassis.	See paragraph 80*c*.
10. Zero beat is obtained in the headset and BLINKER light, but TUNING METER does not deflect.	Defective vtvm tube V109 or associated components.	Check V109 and components. Replace defective part.
	Defective meter	Replace meter.
11. Zero beat obtained in the headset, but BLINKER does not indicate.	Defective blinker amplifier tube V502A or associated components.	Check V502A and components. Replace defective part.
	Defective neon glow BLINKER I 501.	Replace I 501.
12. Zero beat obtained by BLINKER operation, but no zero beat in headset.	Defective bucking amplifier tube V502B or associated components.	Check V502B and components. Replace defective part.
	Defective audio output amplifier tube V502B or associated components.	Check V502B and components. Replace defective part.
	Headset not plugged in properly or defective.	Check headset and replace if defective.
13. No zero beat obtained on any band. TUNING METER operates normally.	Defect in indicator or proxy oscillator-multiplier subchassis.	See paragraph 80*a*.
14. Volume expander action of audio, incorrect or nonexistent.	Defective bucking amplifier tube V501B or associated components.	Check V501 and components. Replace defective part.
	Bucking control R505 improperly set.	Adjust R505 for minimum audio output on a weak (spurious) response.
15. Zero beat obtained on BAND 1 only.	Defective components between output of V102 and input of V107.	See paragraph 80*b*.

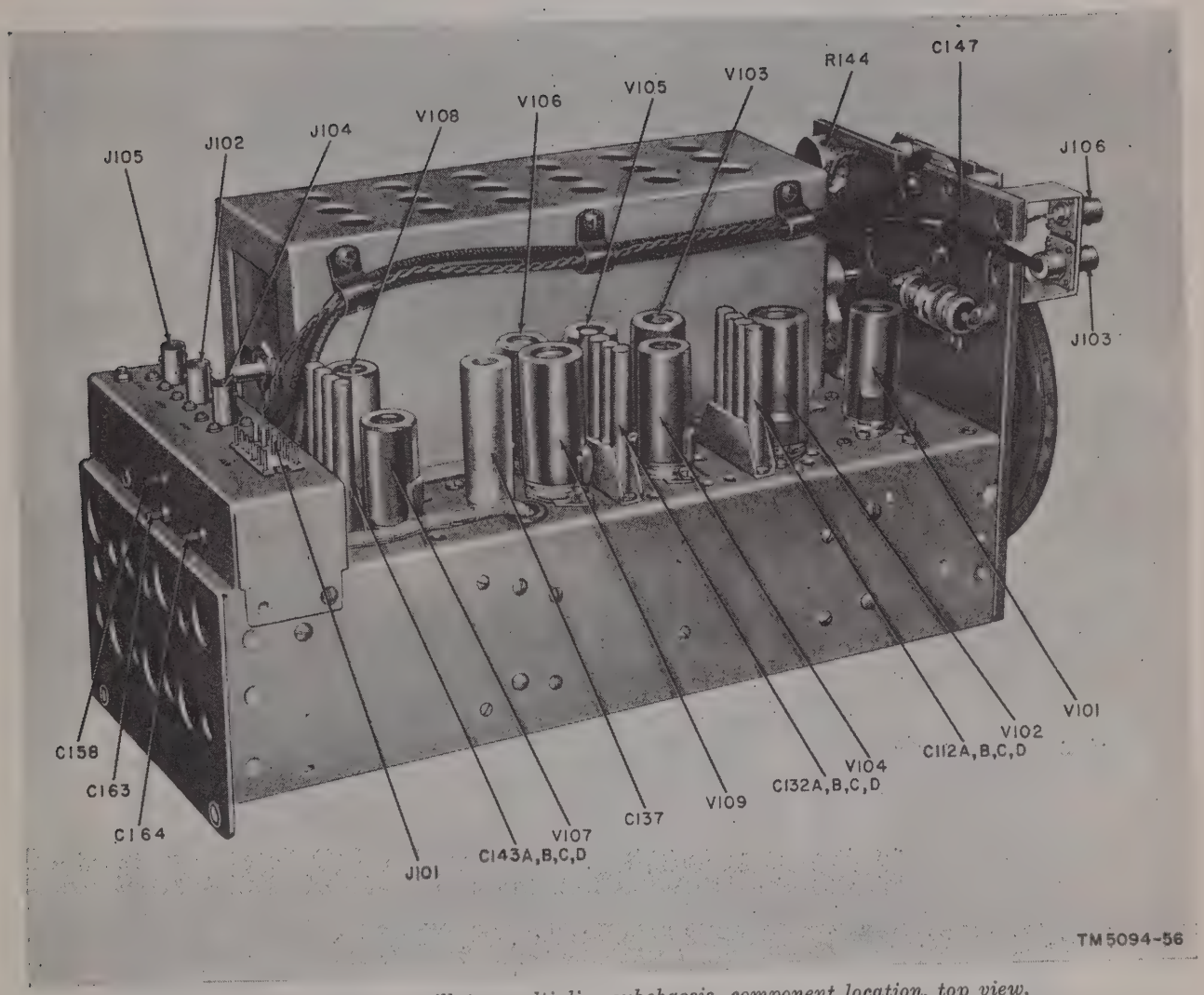


Figure 57. Proxy oscillator-multiplier subchassis, component location, top view.

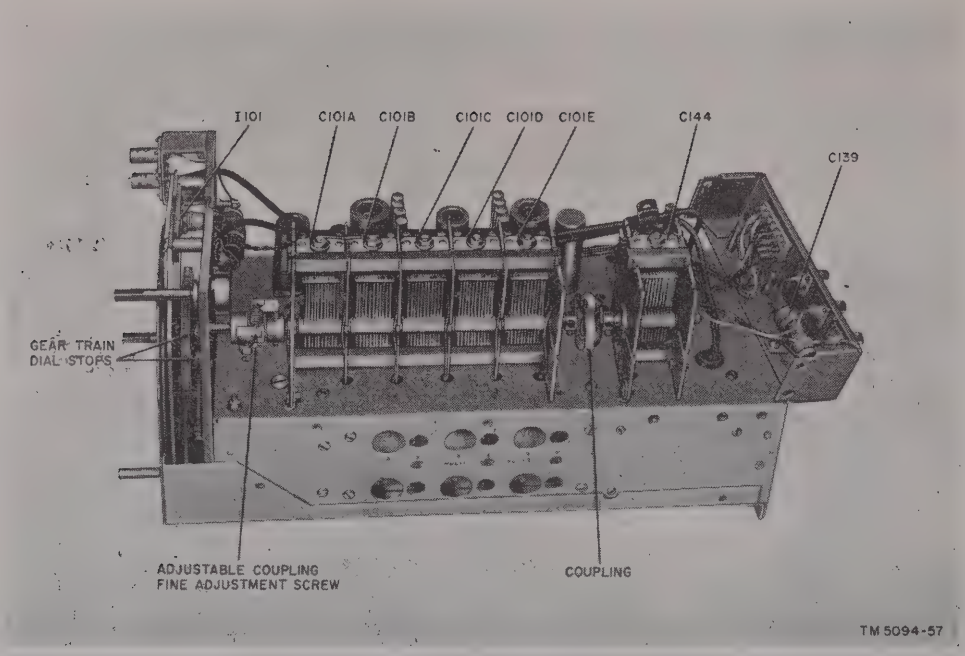


Figure 58. Proxy oscillator-multiplier subchassis, top view, with gang capacitor shield removed and terminal cover tilted, component location.

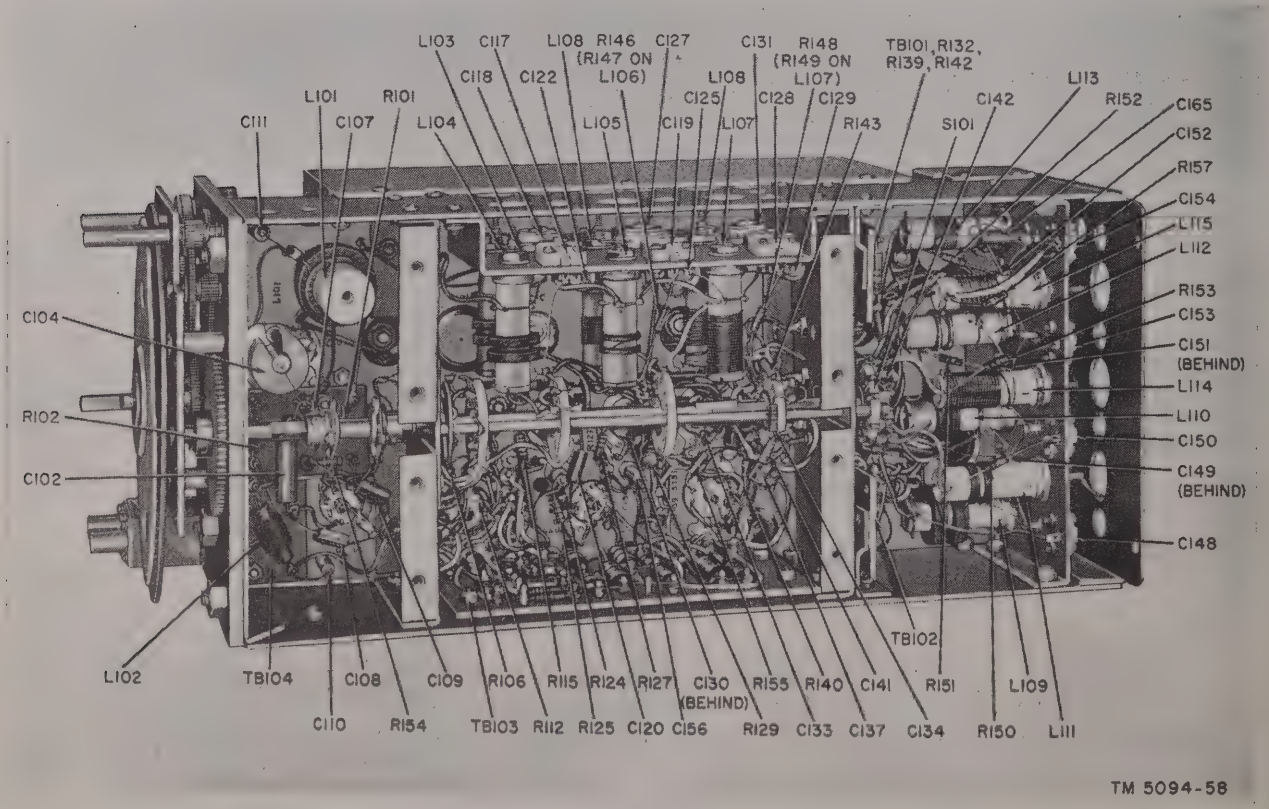


Figure 59. Proxy oscillator-multiplier subchassis, component location, bottom view.

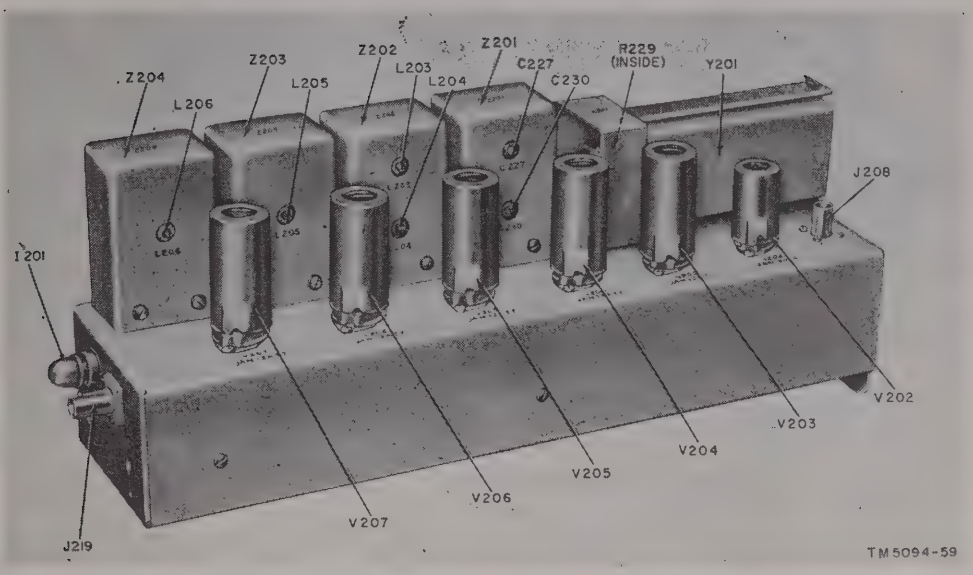


Figure 60. Crystal oscillator-divider subchassis, component location, top view.

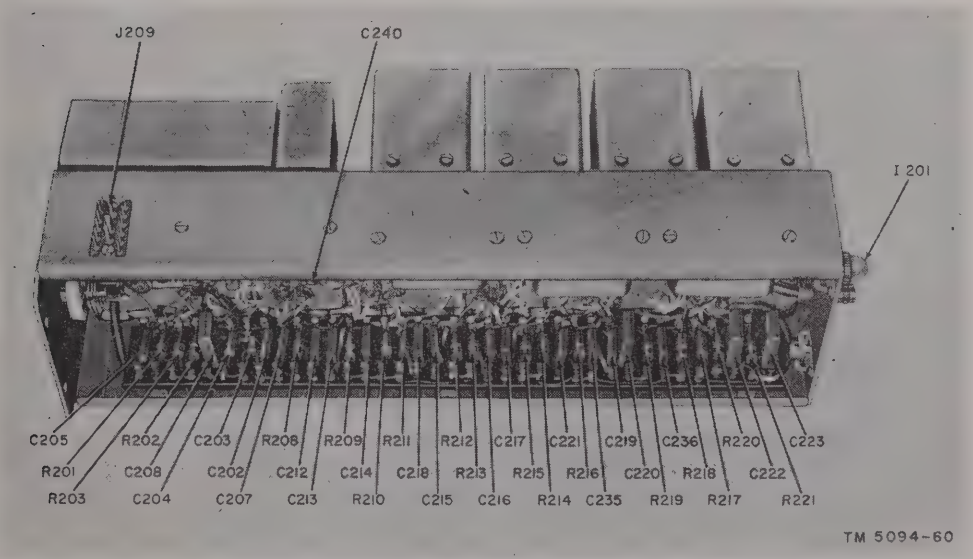


Figure 61. Crystal oscillator-divider subchassis, component location, left bottom view.

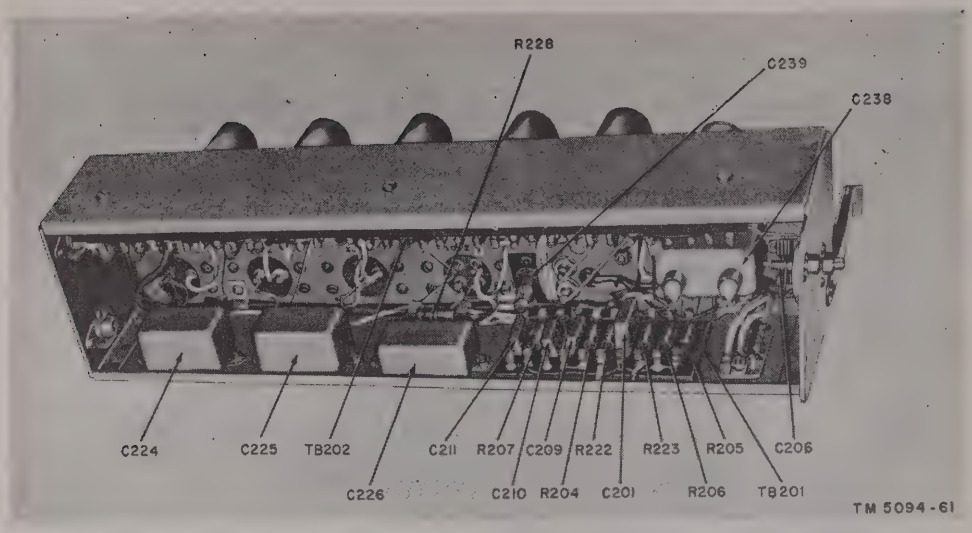


Figure 62. Crystal oscillator-divider subchassis, component location, right bottom view.

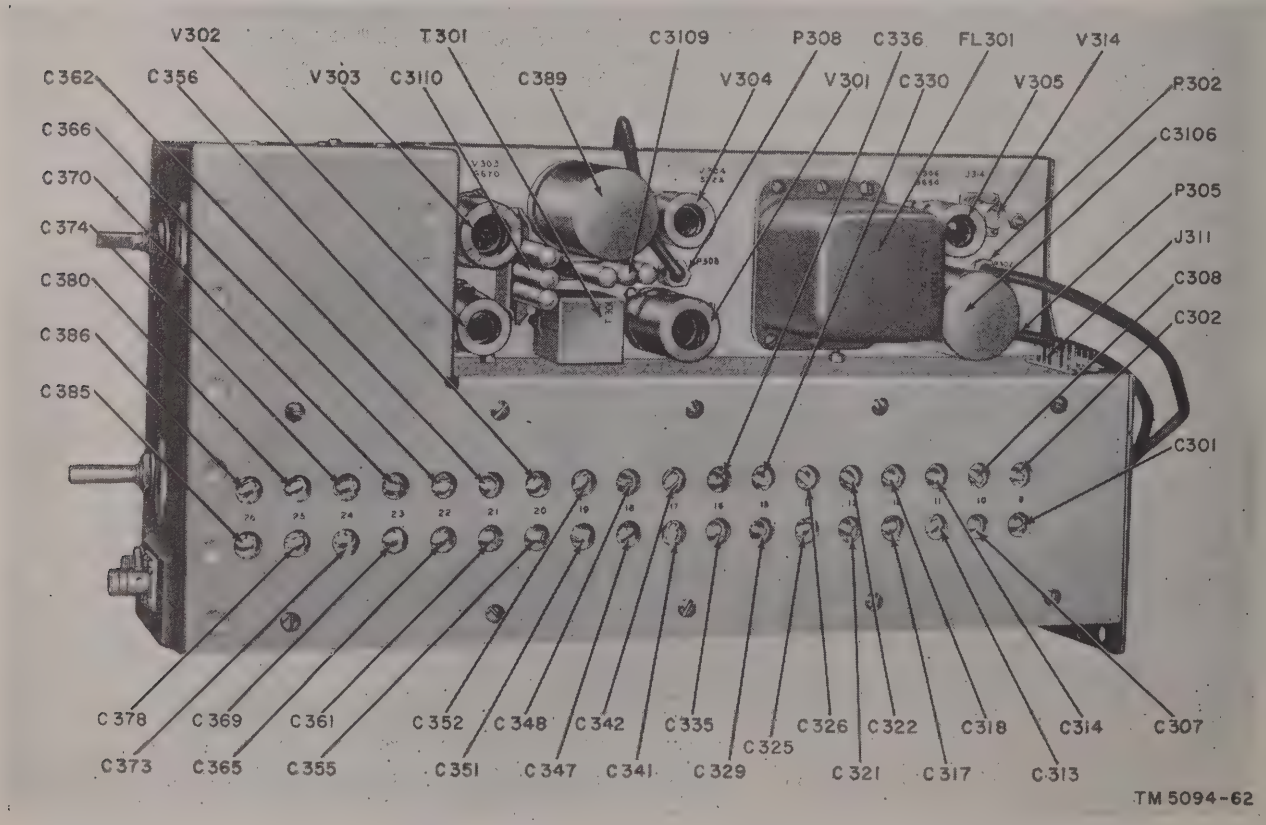


Figure 63. Harmonic selector subchassis, component location, top view.

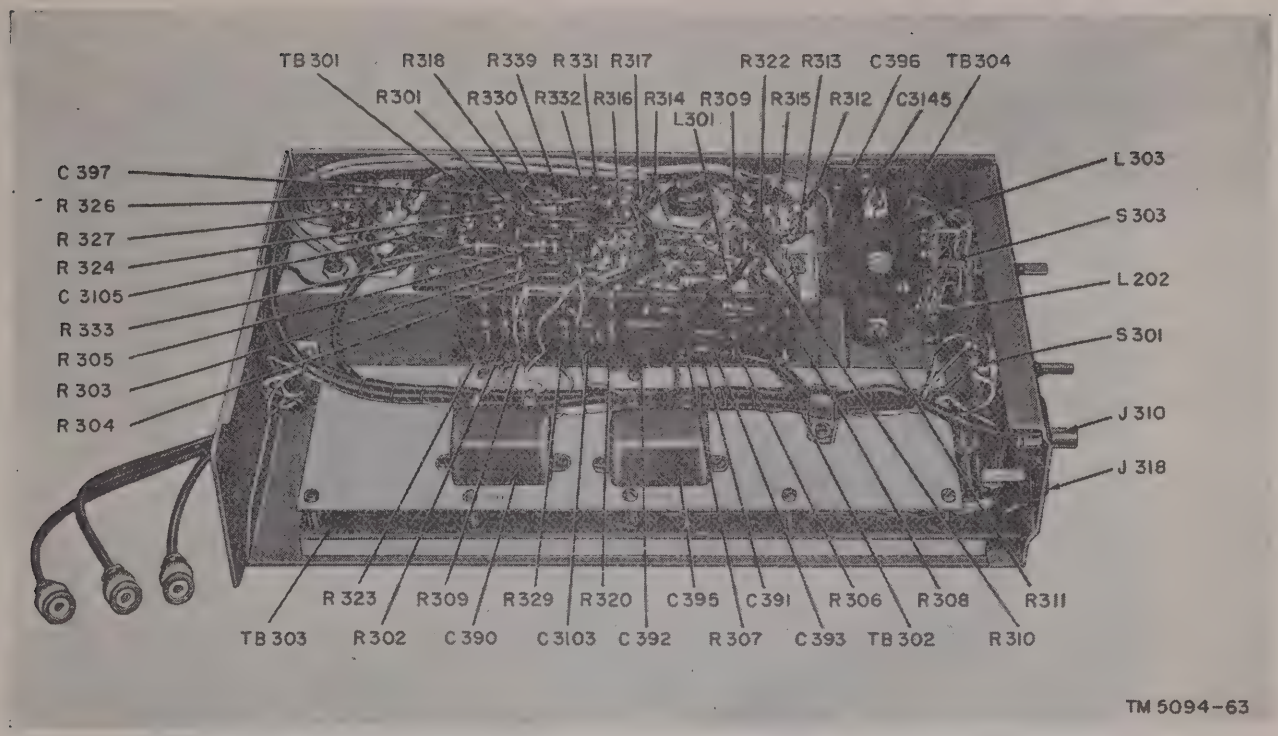


Figure 64. Harmonic selector subchassis, component location, bottom view.

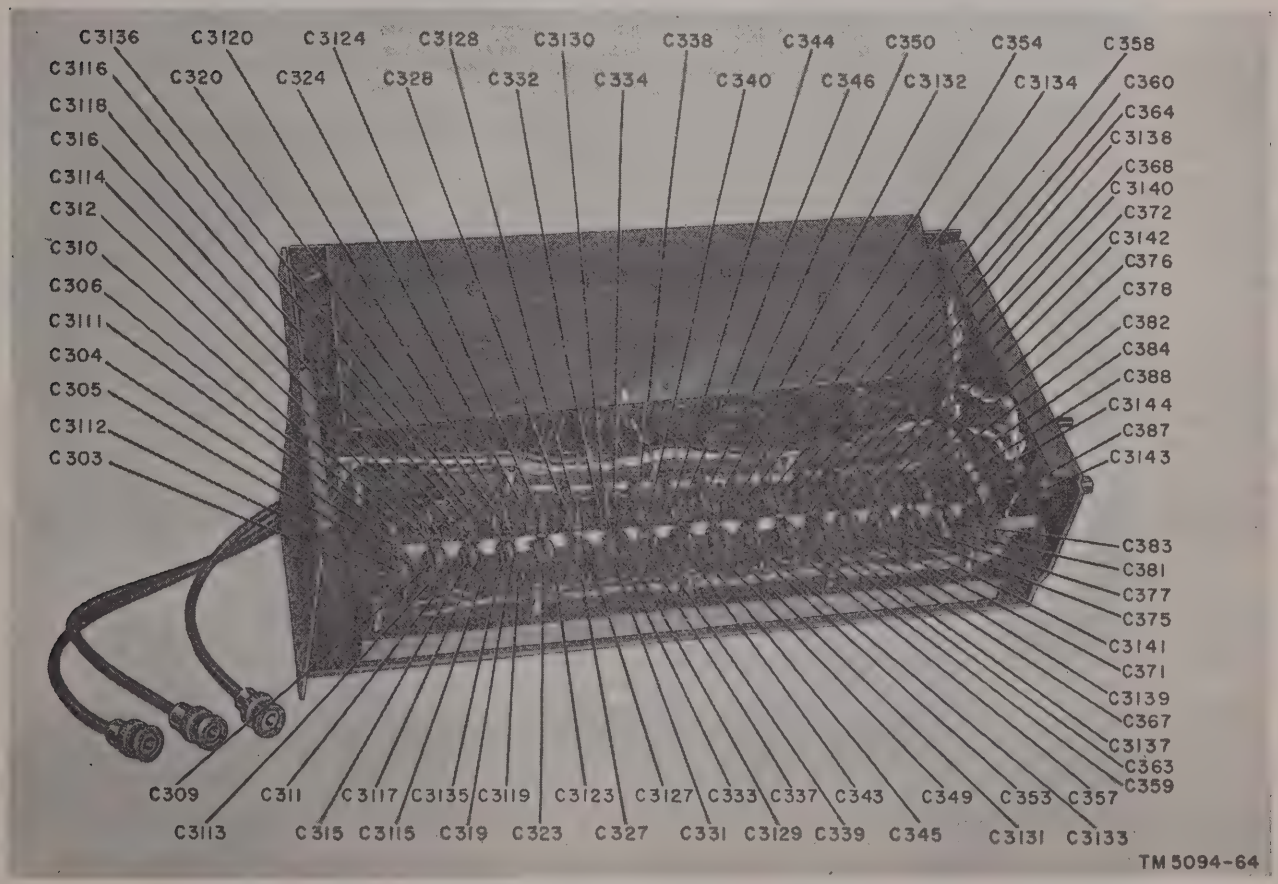


Figure 65. Harmonic selector subchassis, terminal board cover laid back, component location, bottom view.

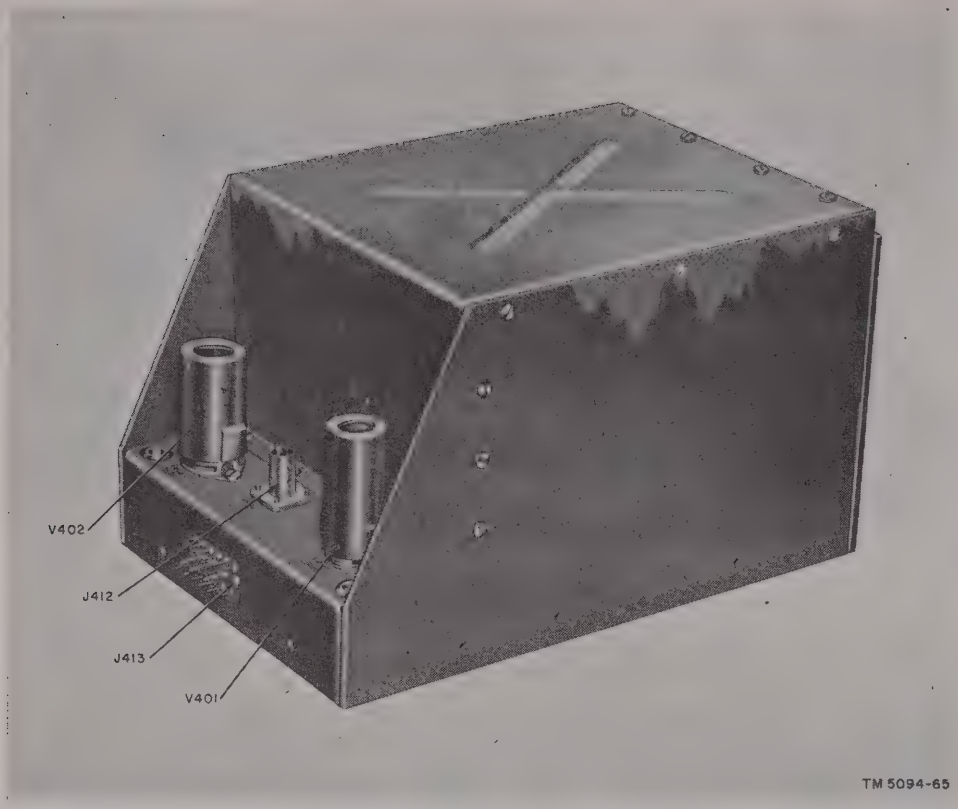


Figure 66. Interpolation oscillator subchassis, component location, top view.

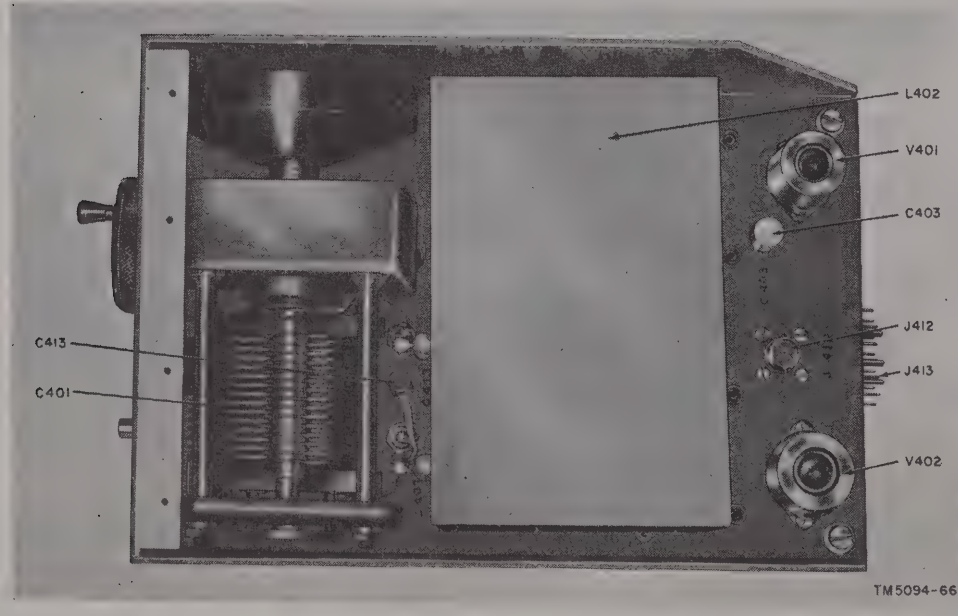


Figure 67. Interpolation oscillator subchassis, cover removed, component location, top view.

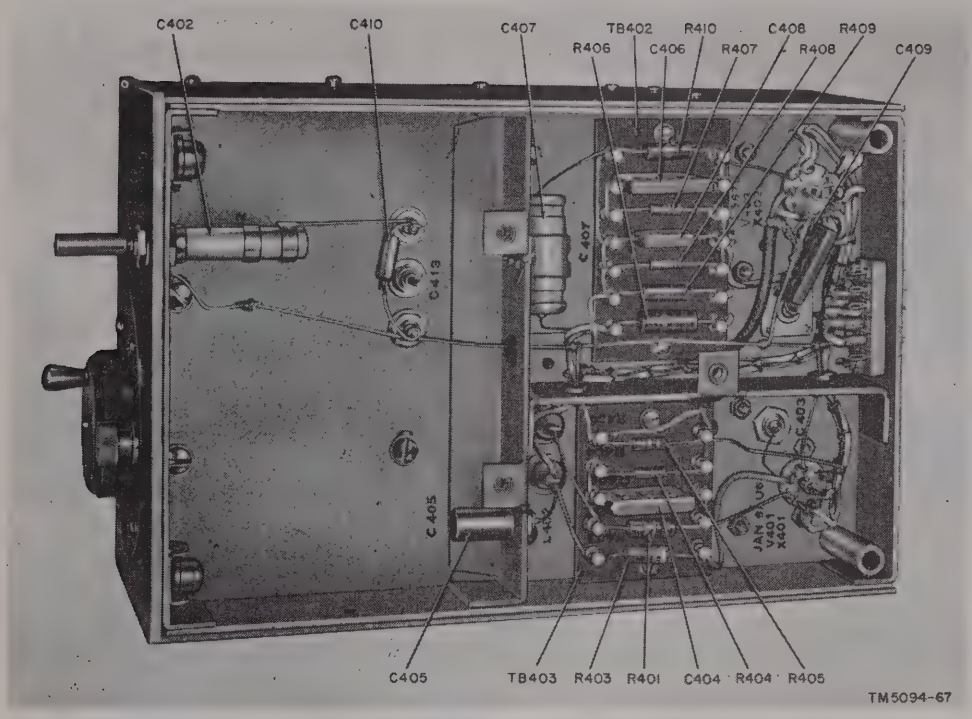


Figure 68. Interpolation oscillator subchassis, component location, bottom view.

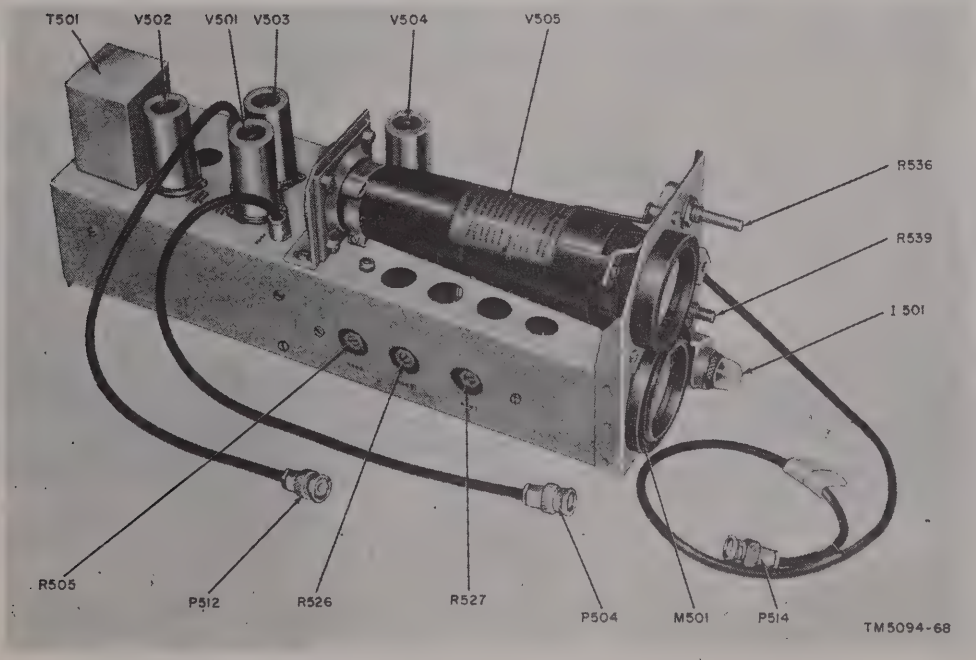


Figure 69. Indicator subchassis, component location, top view.

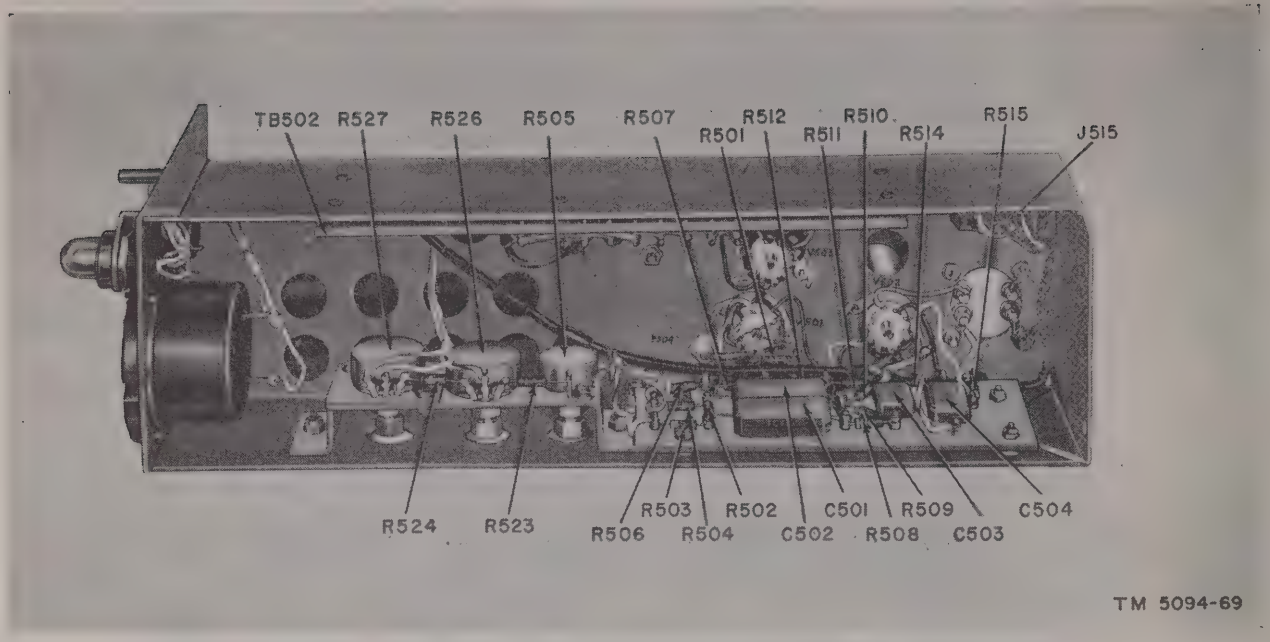


Figure 70. Indicator subchassis, component location, left bottom view.

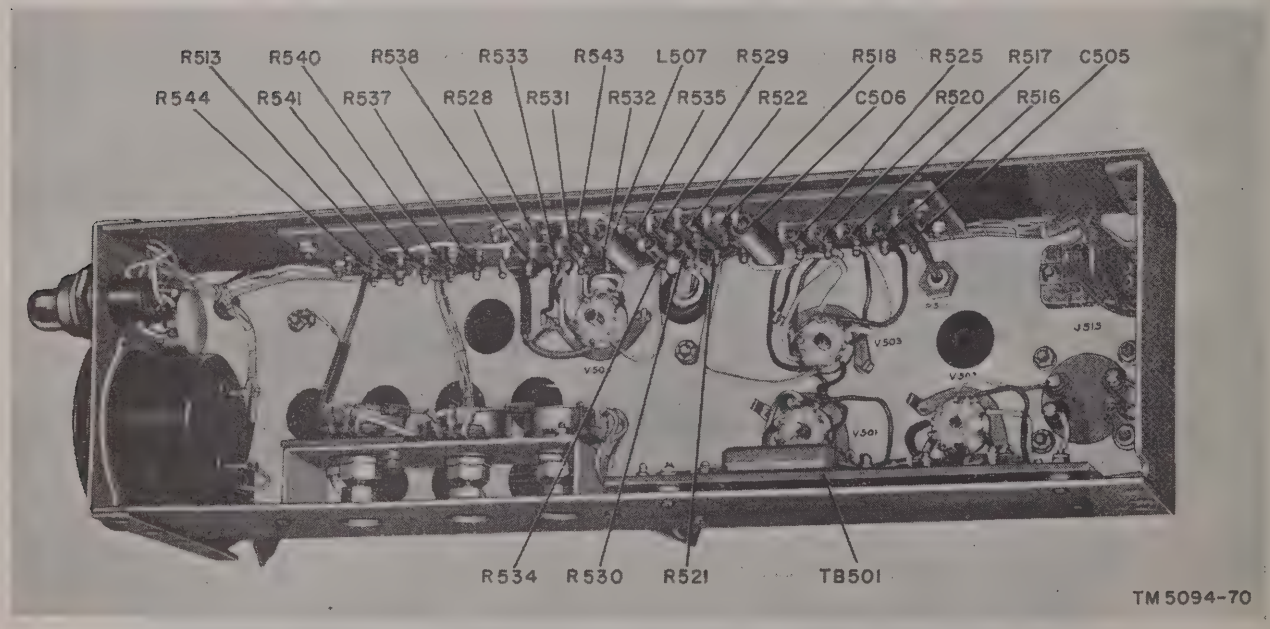


Figure 71. Indicator subchassis, component location, right bottom view.

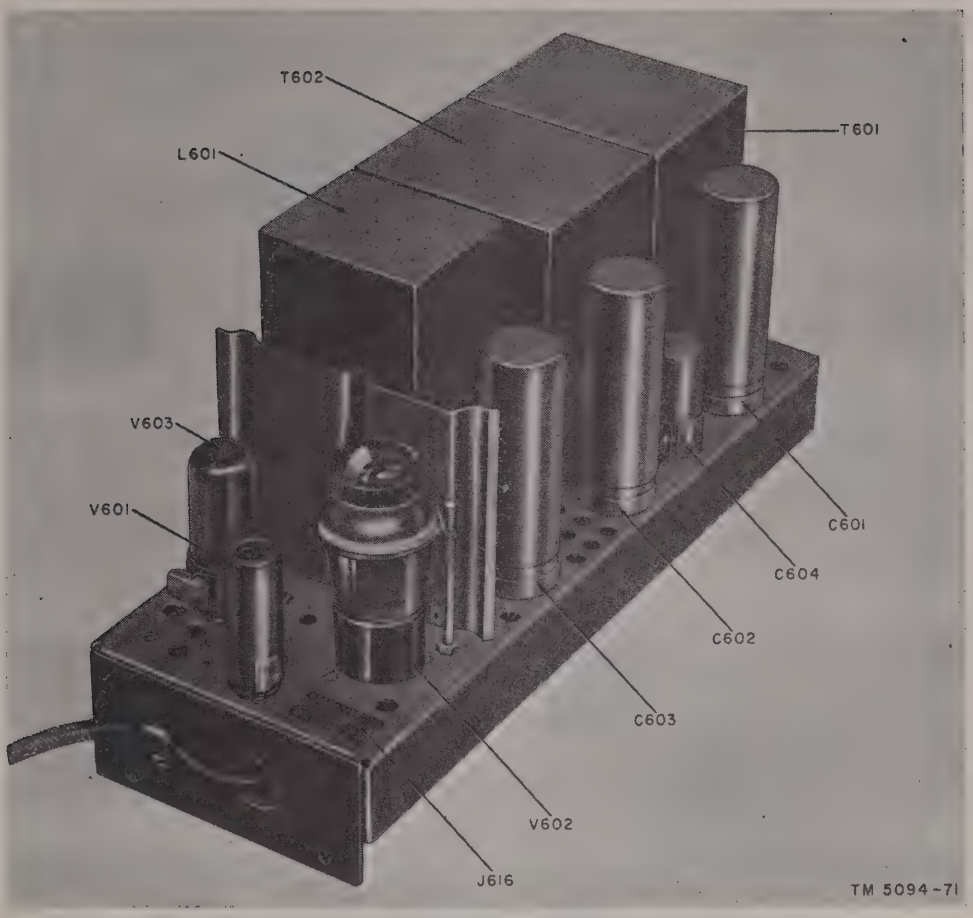


Figure 72. Power supply subchassis, component location, top view.

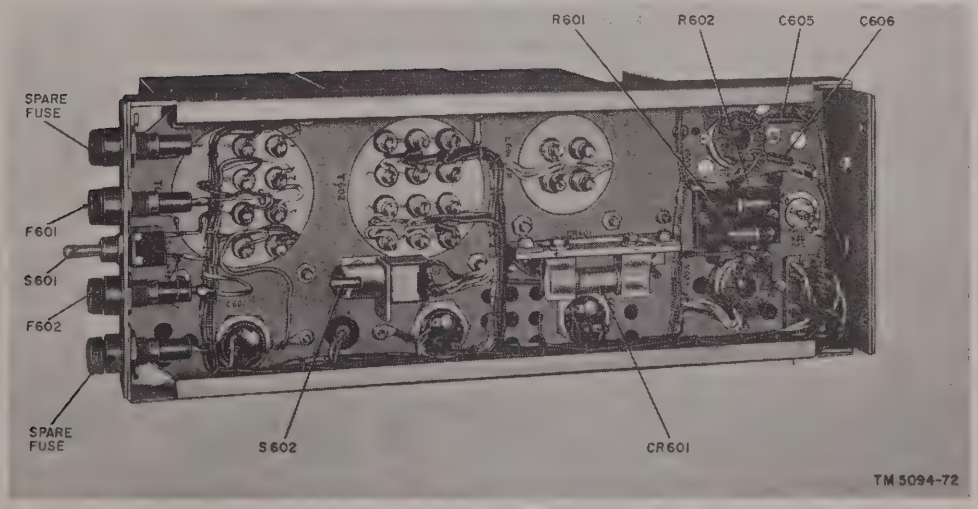


Figure 73. Power supply subchassis, component location, bottom view.

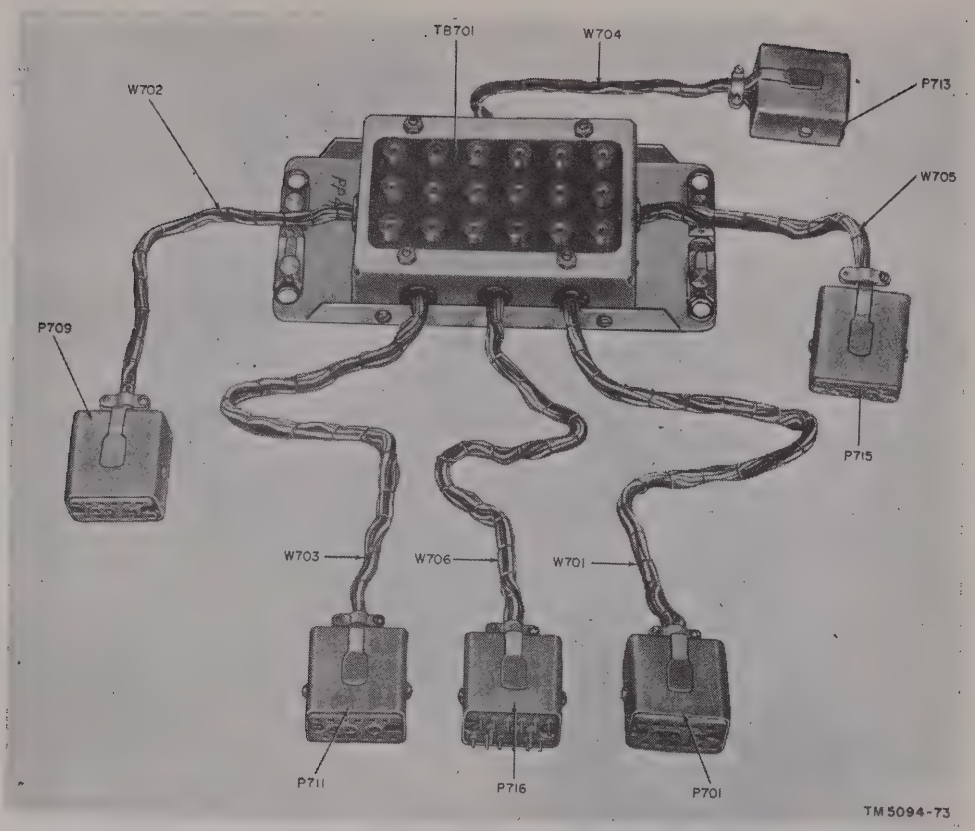
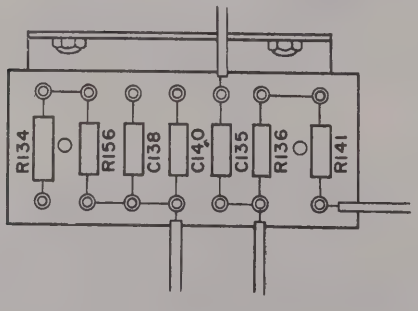
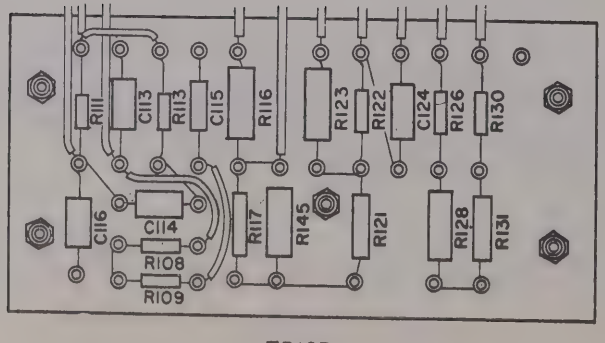


Figure 74. Junction box, component location.



TB102



TB103

TM 5094-74

Figure 75. Terminal boards TB102 and TB3103, component location.

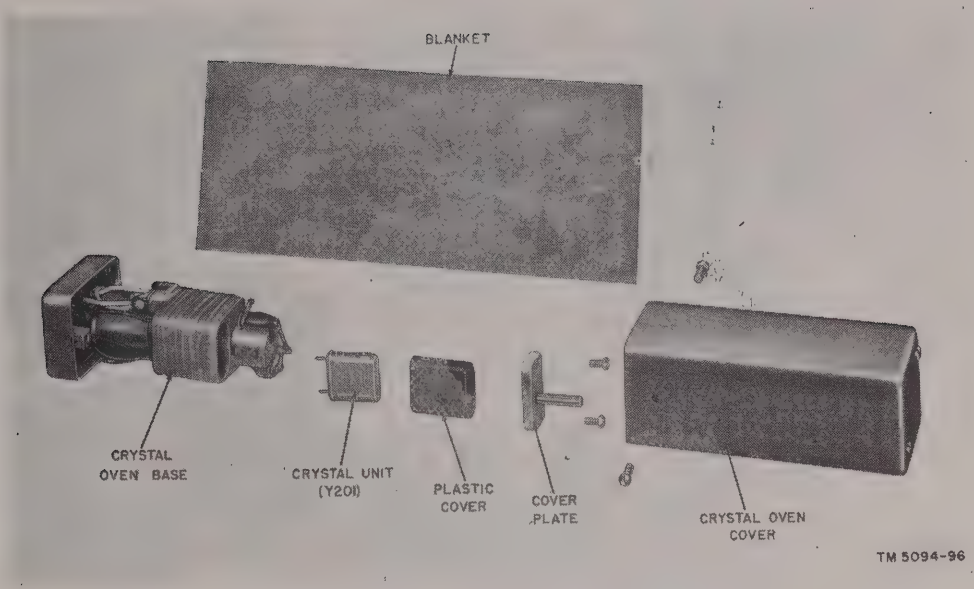
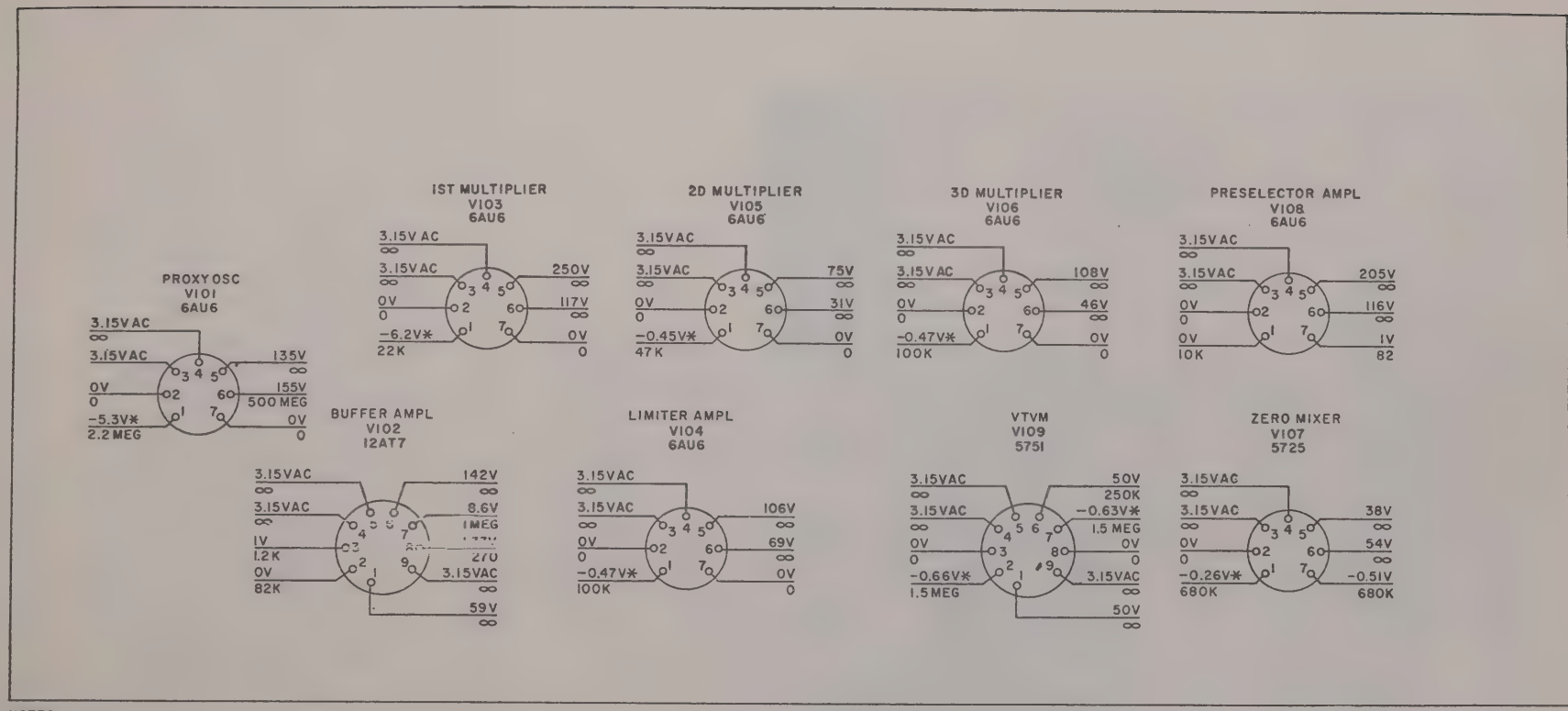


Figure 76. View of disassembled crystal oven.



NOTES:

1. LINE VOLTAGE 115 VOLTS.
2. ALL RESISTANCES ARE IN OHMS.
3. DC VOLTAGES MARKED WITH AN ASTERISK MEASURED WITH ELECTRONIC VOLTMETER. ALL OTHER DC VOLTAGES ARE MEASURED WITH 20,000-OHMS-PER-VOLT VOLTMETER.
4. ALL VOLTAGES MEASURED WITH RESPECT TO CHASSIS GROUND. ALL RESISTANCES MEASURED WITH CHASSIS UNPLUGGED FROM JUNCTION BOX.
5. VOLTAGE READINGS ABOVE LINE. RESISTANCE READINGS BELOW LINE.
6. ALL VOLTAGES MEASURED WITH BAND SWITCH IN BAND 7 POSITION.
7. HARMONIC SELECTOR SWITCH SET TO 9TH HARMONIC POSITION.
8. PROXY OSCILLATOR SET TO LOW FREQUENCY END BAND 7.

TM5094-75

Figure 77. Proxy oscillator-multiplier subchassis, voltage and resistance data.

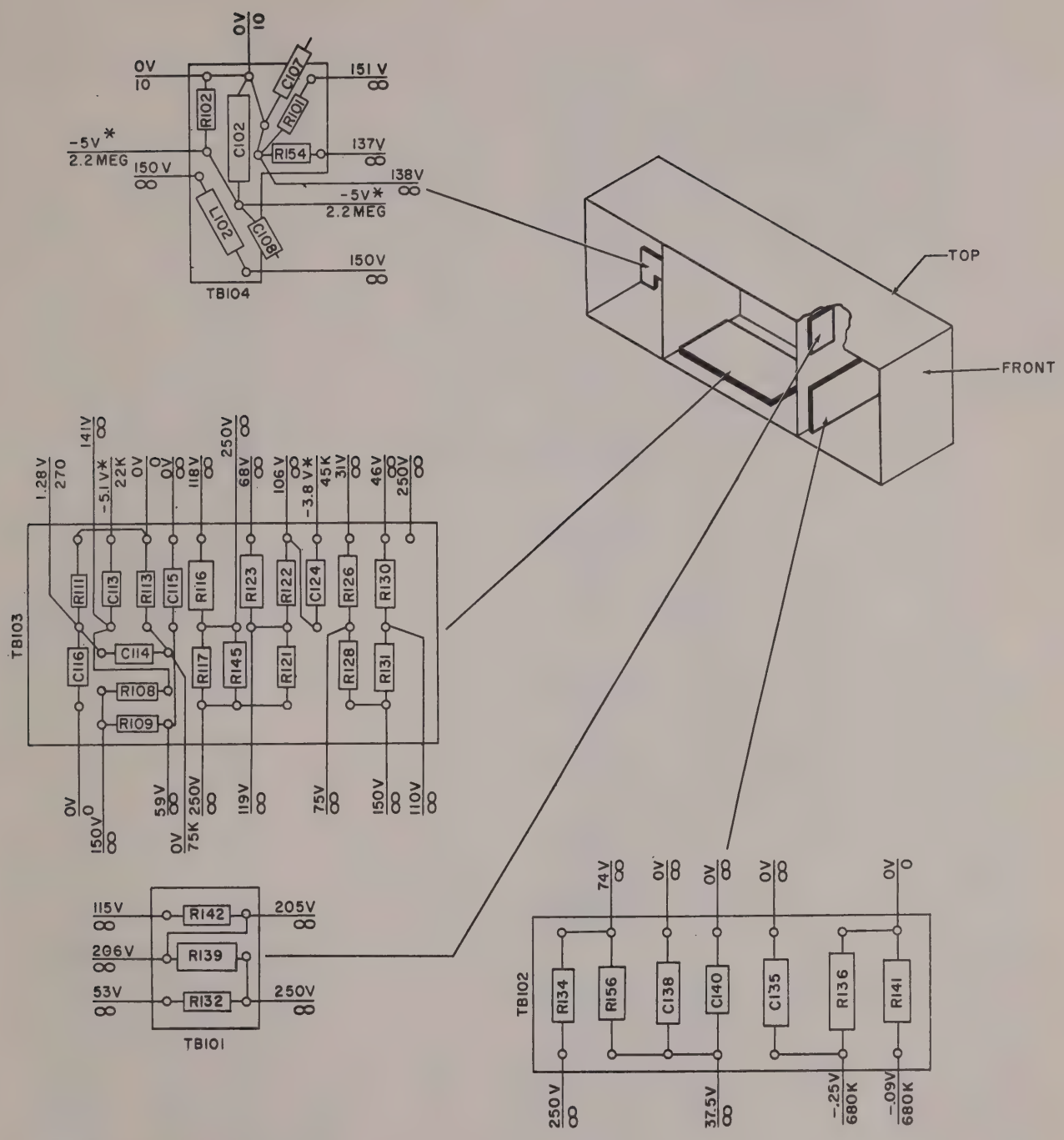
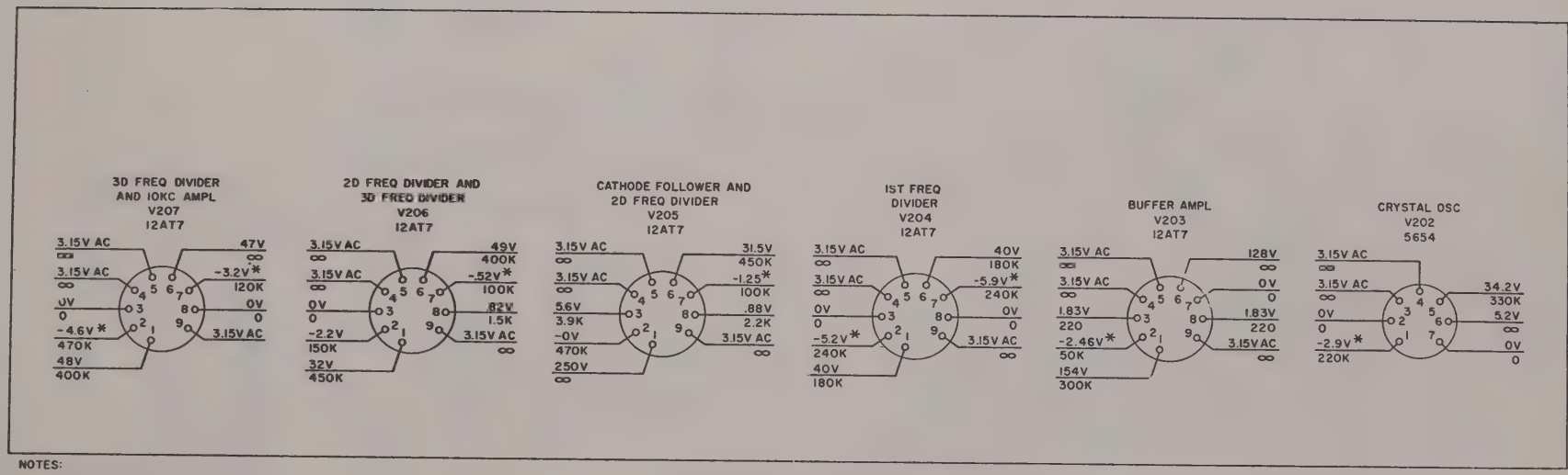


Figure 78. Proxy oscillator-multiplier subchassis, terminal board, voltage and resistance data.

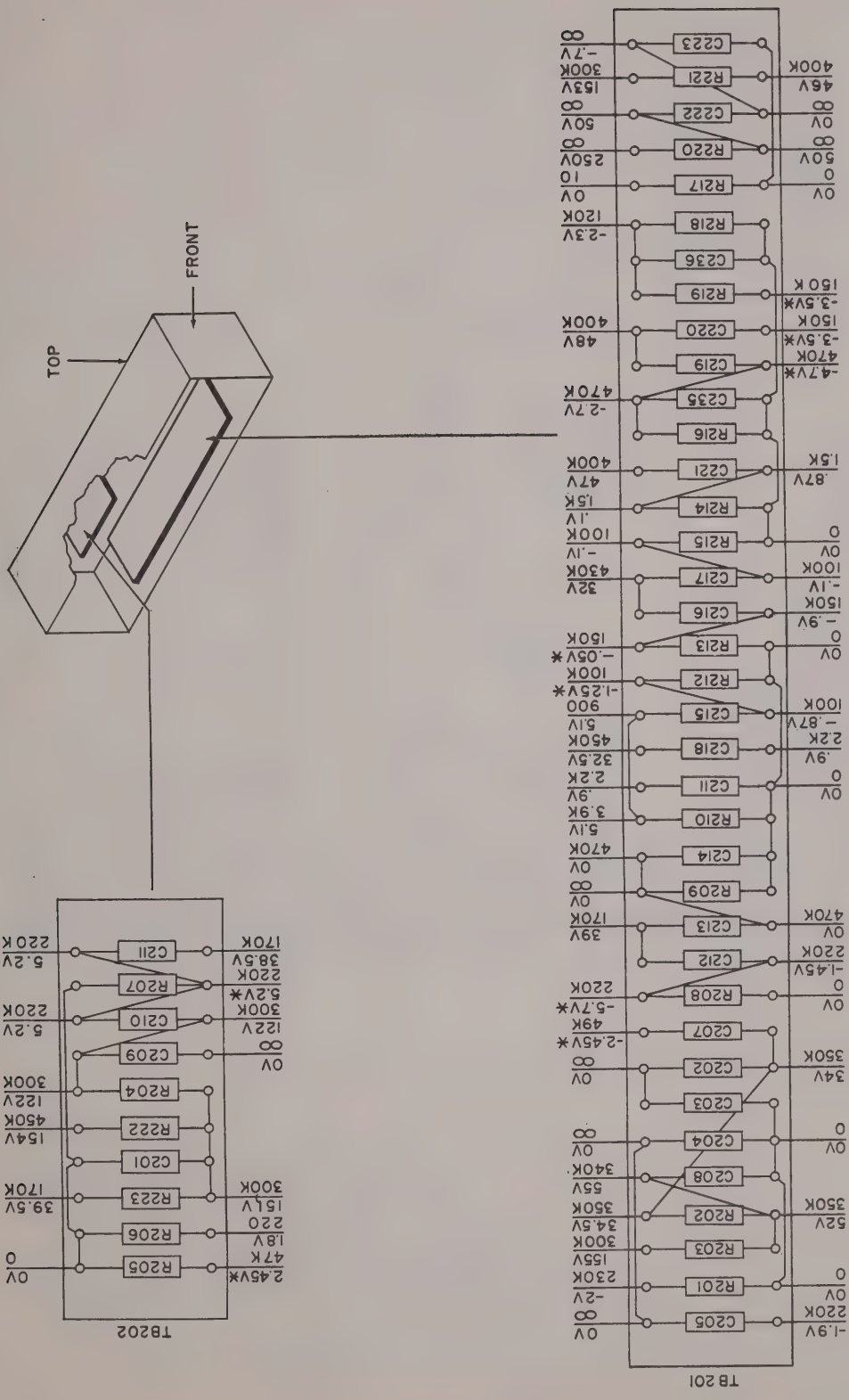


NOTES:

1. LINE VOLTAGE 115 VOLTS.
2. ALL RESISTANCES ARE IN OHMS
3. VOLTAGE READINGS ABOVE LINE. RESISTANCE READINGS BELOW LINE
4. DC VOLTAGES MARKED WITH ASTERISK MEASURED WITH ELECTRONIC VOLTMETER. ALL OTHER DC VOLTAGES MEASURED WITH 20,000-OHMS-PER-VOLT VOLTMETER.
5. ALL VOLTAGES MEASURED WITH RESPECT TO CHASSIS GROUND. ALL RESISTANCES MEASURED WITH CHASSIS UNPLUGGED FROM JUNCTION BOX.

TM 5094-77

Figure 79. Crystal oscillator-divider subchassis, voltage and resistance data.

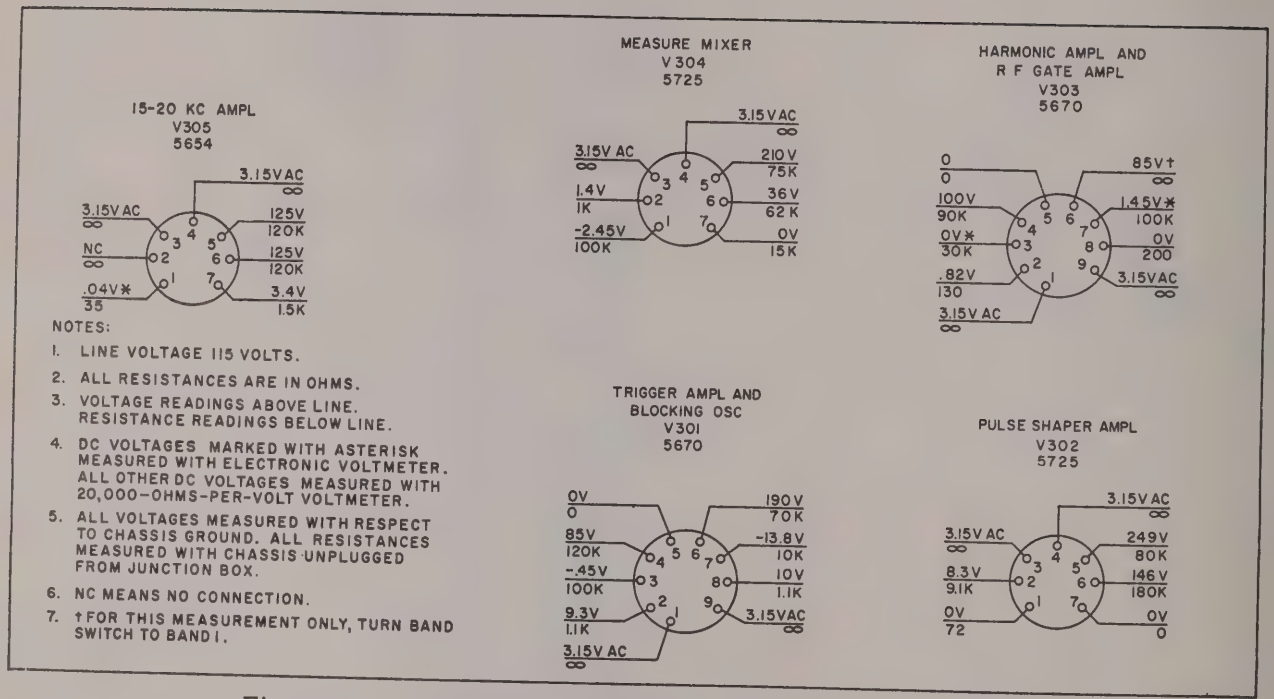


NOTES:

1. LINE VOLTAGE 115 VOLTS.
2. ALL RESISTANCES ARE IN OHMS.
3. VOLTAGE READINGS ABOVE LINE, RESISTANCE READINGS BELOW LINE.
4. DC VOLTAGES MARKED WITH ASTERISK MEASURED WITH ELECTRONIC VOLTMETER. ALL OTHER DC VOLTAGES MEASURED WITH 20,000-OHMS-PER-VOLT VOLTMETER.
5. ALL VOLTAGES MEASURED WITH RESPECT TO CHASSIS GROUND. ALL RESISTANCES MEASURED WITH CHASSIS UNPLUGGED FROM JUNCTION BOX.

TM 5094-78

Figure 80. Crystal oscillator-divider subchassis, terminal board, voltage and resistance data.

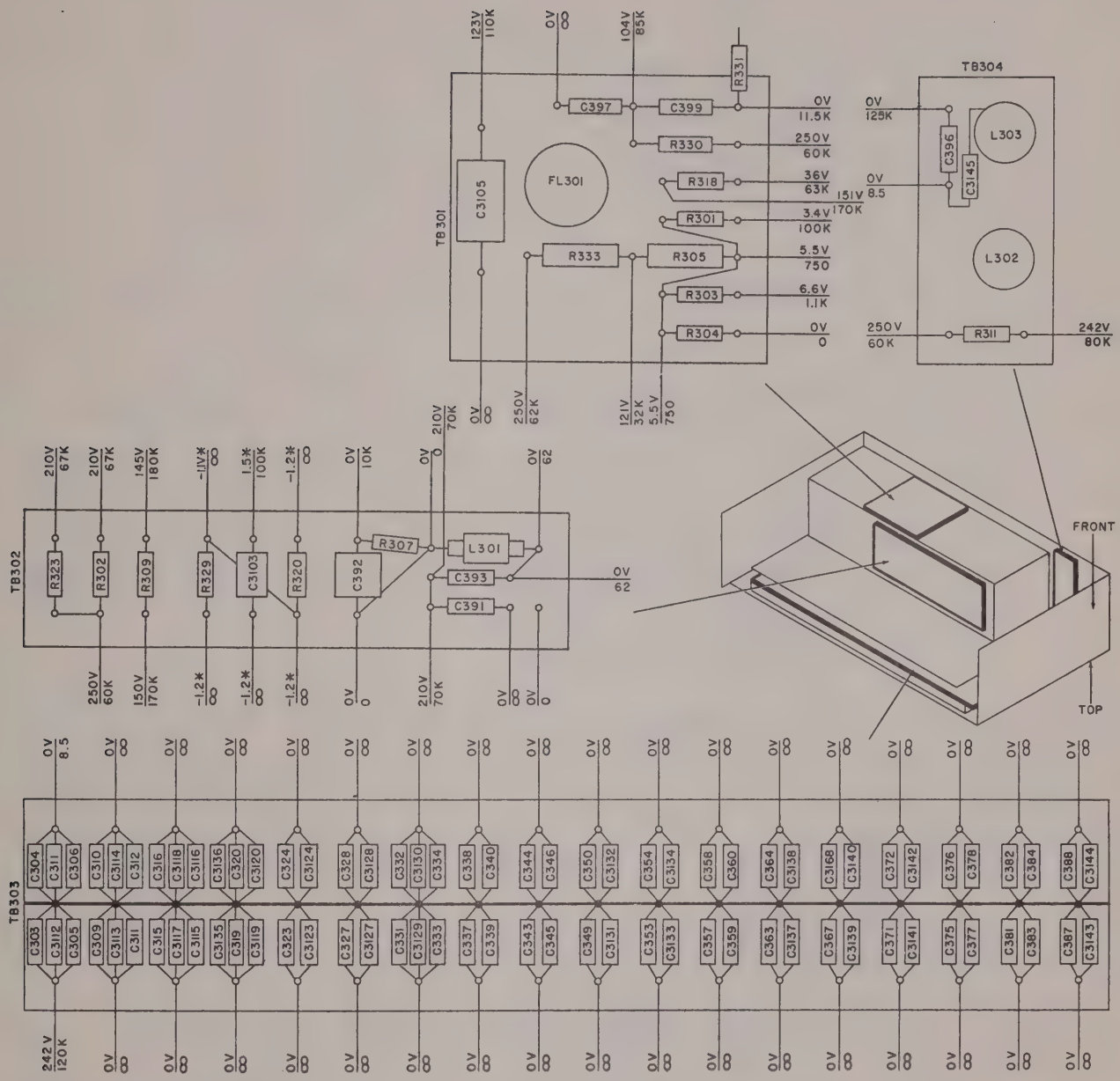


NOTES:

1. LINE VOLTAGE 115 VOLTS.
2. ALL RESISTANCES ARE IN OHMS.
3. VOLTAGE READINGS ABOVE LINE. RESISTANCE READINGS BELOW LINE.
4. DC VOLTAGES MARKED WITH ASTERISK MEASURED WITH ELECTRONIC VOLTMETER. ALL OTHER DC VOLTAGES MEASURED WITH 20,000-OHMS-PER-VOLT VOLTMETER.
5. ALL VOLTAGES MEASURED WITH RESPECT TO CHASSIS GROUND. ALL RESISTANCES MEASURED WITH CHASSIS UNPLUGGED FROM JUNCTION BOX.
6. NC MEANS NO CONNECTION.
7. †FOR THIS MEASUREMENT ONLY, TURN BAND SWITCH TO BAND 1.

Figure 81. Harmonic selector subchassis, voltage and resistance data.

TM 5094-79

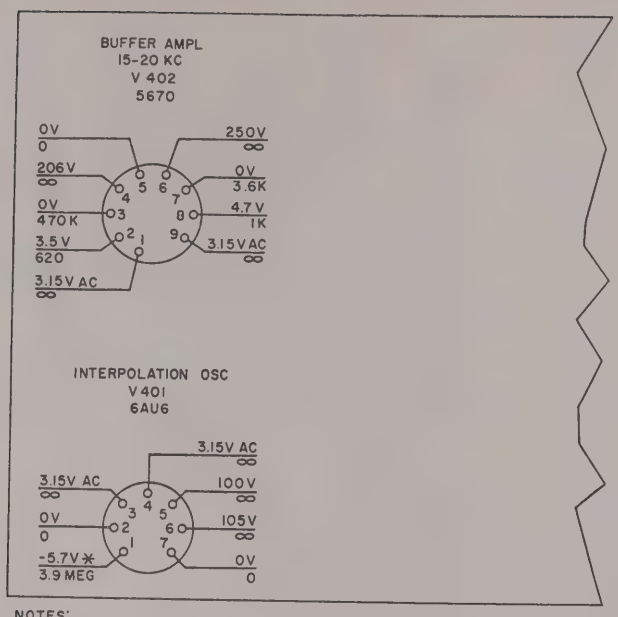


NOTES:

1. LINE VOLTAGE 115 VOLTS.
2. ALL RESISTANCES ARE IN OHMS.
3. VOLTAGE READINGS ABOVE LINE AND RESISTANCE READINGS BELOW LINE.
4. DC VOLTAGES MARKED WITH AN ASTERISK MEASURED WITH ELECTRONIC VOLTMETER. ALL OTHER DC VOLTAGES ARE MEASURED WITH 20,000-OHMS-PER-VOLT VOLTMETER.
5. ALL VOLTAGES MEASURED TO CHASSIS GROUND. ALL RESISTANCES MEASURED WITH CHASSIS UNPLUGGED FROM JUNCTION BOX.
6. MEASUREMENTS SHOWN FOR TB303 MADE WITH HARMONIC NO. SWITCH IN 9TH HARMONIC POSITION. THESE READINGS ARE OBTAINED ONLY AT THE TERMINALS OF TB303 ENERGIZED BY THE HARMONIC NO. SWITCH. REMAINING TERMINALS OF TB303 SHOW NO VOLTAGES AND INFINITE RESISTANCES.

TM 5094-80

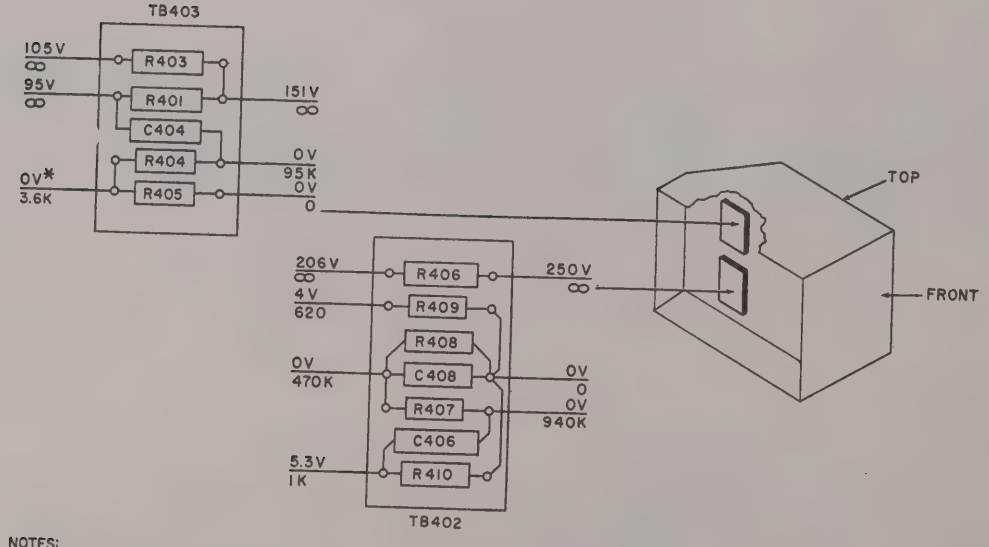
Figure 82. Harmonic selector subchassis, terminal board, voltage and resistance data.



NOTES:
1. LINE VOLTAGE 115 VOLTS.
2. ALL RESISTANCES ARE IN OHMS.
3. DC VOLTAGES MARKED WITH ASTERISK MEASURED WITH ELECTRONIC VOLTMETER. ALL OTHER DC VOLTAGES MEASURED WITH 20,000-OHMS-PER-VOLT VOLTMETER.
4. ALL VOLTAGES MEASURED WITH RESPECT TO CHASSIS GROUND. ALL RESISTANCES MEASURED WITH CHASSIS UNPLUGGED FROM JUNCTION BOX.
5. VOLTAGE READINGS ABOVE LINE, RESISTANCE READINGS BELOW LINE.

TM 5094-81

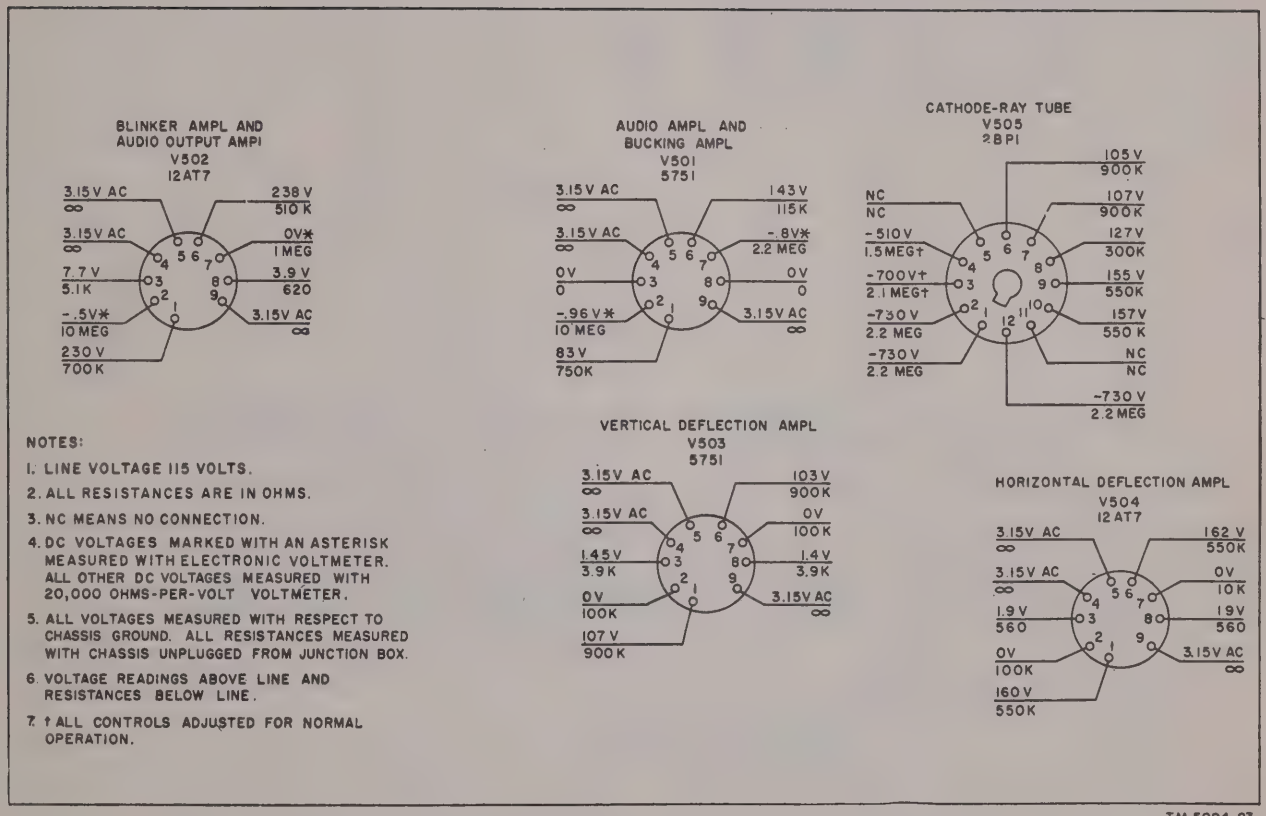
Figure 83. Interpolation oscillator subchassis, voltage and resistance data.



NOTES:
1. LINE VOLTAGE 115 VOLTS.
2. ALL RESISTANCES ARE IN OHMS.
3. VOLTAGE READINGS ABOVE LINE. RESISTANCE READINGS BELOW LINE.
4. DC VOLTAGES MARKED WITH ASTERISK MEASURED WITH ELECTRONIC VOLTMETER. ALL OTHER DC VOLTAGES MEASURED WITH 20,000-OHMS-PER-VOLT VOLTMETER.
5. ALL VOLTAGES MEASURED WITH RESPECT TO CHASSIS GROUND. ALL RESISTANCES MEASURED WITH CHASSIS UNPLUGGED FROM JUNCTION BOX.

TM 5094-82

Figure 84. Interpolation oscillator subchassis, terminal board, voltage and resistance data.

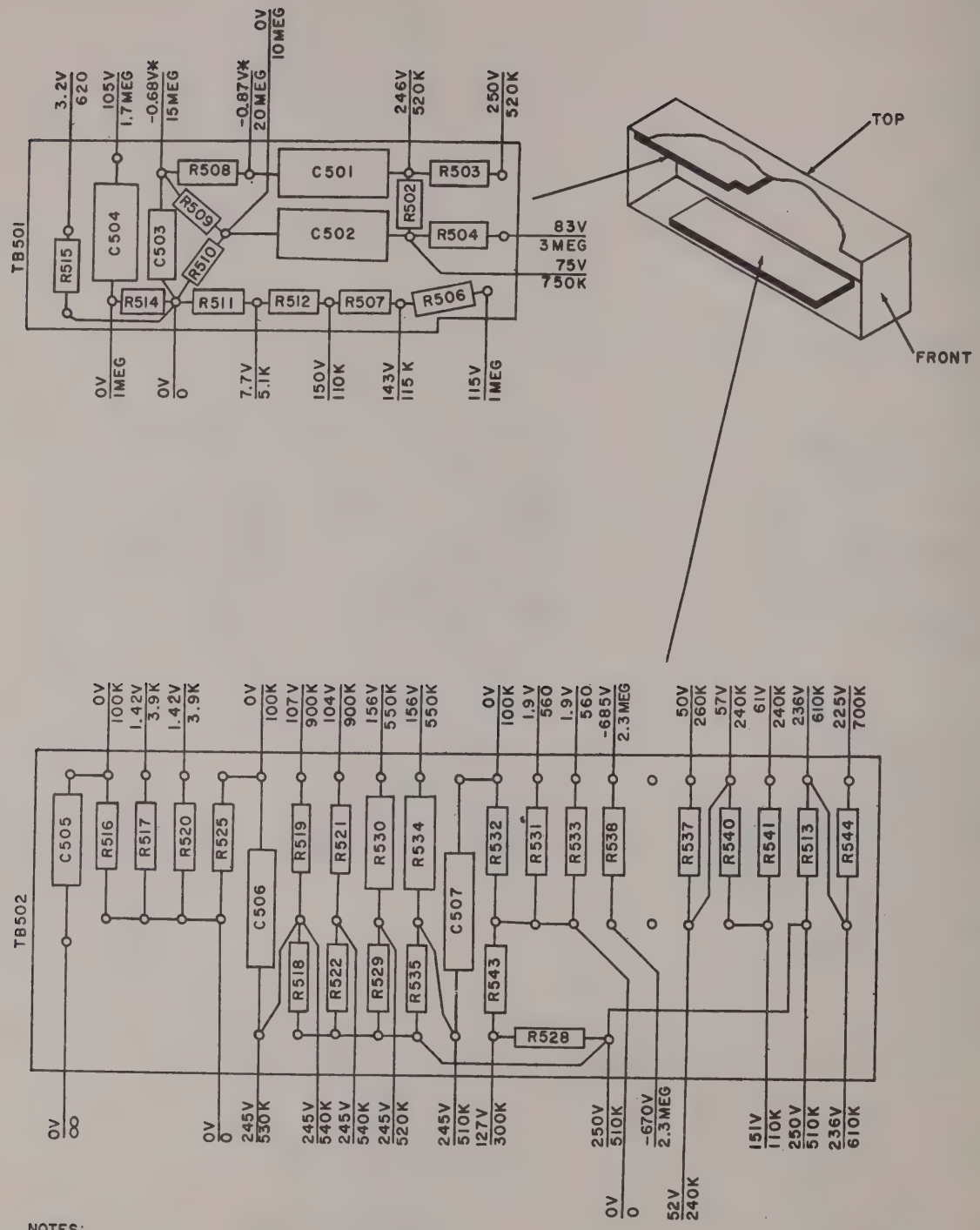


NOTES:

1. LINE VOLTAGE 115 VOLTS.
2. ALL RESISTANCES ARE IN OHMS.
3. NC MEANS NO CONNECTION.
4. DC VOLTAGES MARKED WITH AN ASTERISK MEASURED WITH ELECTRONIC VOLTMETER. ALL OTHER DC VOLTAGES MEASURED WITH 20,000 OHMS-PER-VOLT VOLTMETER.
5. ALL VOLTAGES MEASURED WITH RESPECT TO CHASSIS GROUND. ALL RESISTANCES MEASURED WITH CHASSIS UNPLUGGED FROM JUNCTION BOX.
6. VOLTAGE READINGS ABOVE LINE AND RESISTANCES BELOW LINE.
7. † ALL CONTROLS ADJUSTED FOR NORMAL OPERATION.

TM 5094-83

Figure 85. Indicator subchassis, voltage and resistance data.

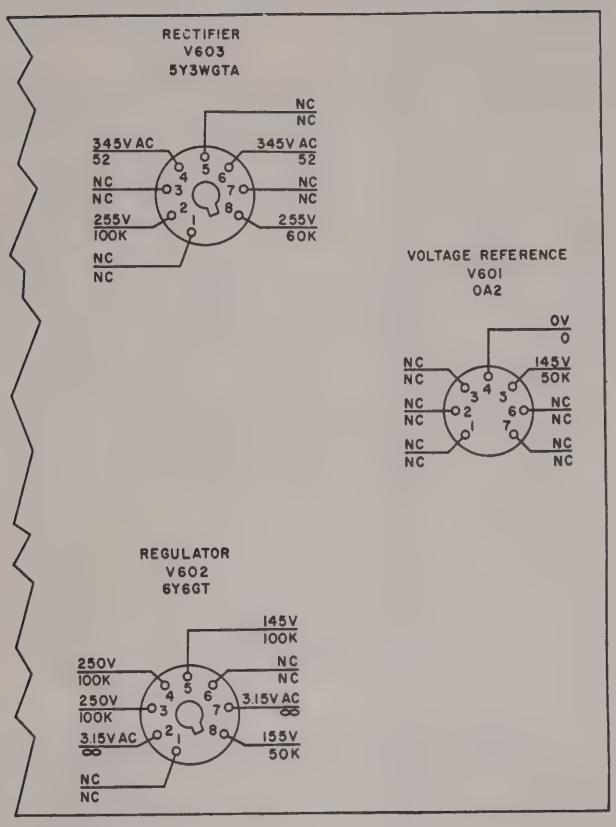


NOTES:

1. LINE VOLTAGE 115 VOLTS.
2. ALL RESISTANCES ARE IN OHMS.
3. VOLTAGE READINGS ABOVE LINE. RESISTANCE READINGS BELOW LINE.
4. DC VOLTAGES MARKED WITH ASTERISK MEASURED WITH ELECTRONIC VOLTMETER. ALL OTHER DC VOLTAGES MEASURED WITH 20,000-OHMS-PER-VOLT VOLTMETER.
5. ALL VOLTAGES MEASURED WITH RESPECT TO CHASSIS GROUND. ALL RESISTANCES MEASURED WITH CHASSIS UNPLUGGED FROM JUNCTION BOX.

TM 5094-84

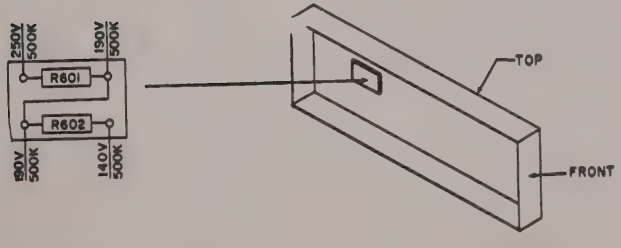
Figure 86. Indicator subchassis, terminal board, voltage and resistance data.



NOTES:
1. LINE VOLTAGE 115 VOLTS.
2. ALL RESISTANCES ARE IN OHMS.
3. NC MEANS NO CONNECTION.
4. DC VOLTAGES MEASURED WITH 20,000-OHMS-PER-VOLT VOLTMETER.
5. ALL VOLTAGES MEASURED WITH RESPECT TO CHASSIS GROUND. ALL RESISTANCES MEASURED WITH CHASSIS UNPLUGGED FROM JUNCTION BOX.
6. VOLTAGE READINGS ABOVE LINE, RESISTANCE READINGS BELOW LINE.

TM 5094-85

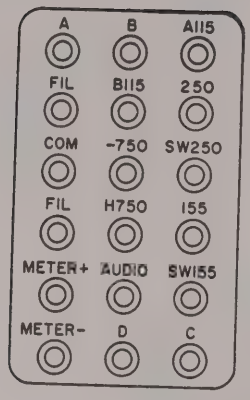
Figure 87. Power supply subchassis, voltage and resistance data.



NOTES.
1. LINE VOLTAGE 115 VOLTS.
2. ALL VOLTAGES MEASURED TO CHASSIS GROUND. ALL RESISTANCES MEASURED WITH CHASSIS UNPLUGGED FROM JUNCTION BOX.
3. ALL VOLTAGES MEASURED WITH 20,000-OHMS-PER-VOLT VOLTMETER.
4. VOLTAGE READINGS ABOVE LINE AND RESISTANCE BELOW LINE.
5. ALL RESISTANCE READINGS ARE IN OHMS.

TM 5094-86

Figure 88. Power supply subchassis, terminal board, voltage and resistance data.



TERMINALS	RESISTANCE	VOLTAGE	TERMINALS	RESISTANCE	VOLTAGE	TERMINALS	RESISTANCE	VOLTAGE
A	∞	0V	B	∞	0V	A115	∞	115V *
FIL	∞	3.15 V AC	B115	∞	115V *	250	∞	250V
COM	∞	0V	-750	∞	-730V	SW250	∞	0V
FIL	∞	3.15 V AC	H750	∞	-730V	155	∞	155V
METER+	∞	56V	AUDIO	∞	0V	SW155	∞	155V
METER-	∞	54V	D	∞	0V	C	∞	0V

NOTES:
1. LINE VOLTAGE 115 VOLTS.
2. ALL VOLTAGES MEASURED WITH 20,000-OHMS-PER-VOLT VOLTMETER.
3. ALL VOLTAGES MEASURED WITH RESPECT TO CHASSIS GROUND.
4. * LINE VOLTAGE, MEASURED BETWEEN A115 AND B115.
5. ALL RESISTANCES INFINITE BECAUSE JUNCTION BOX DISCONNECTED FROM ALL SUBCHASSIS WHEN MEASURING RESISTANCE.

TM 5094-87

Figure 89. Junction box, voltage and resistance data.

78. Dc Resistances of Transformers and Coils

The d-c resistances of the transformers and coils in Frequency Meter FR–4/U are listed below:

Transformer or coil	Terminals	Ohms
T101	Primary	1.9.
	Secondary	15.
L102		24.
L103		9.3.
L104		3.3.
L105		2.
L106		1.
L107		Continuity.
L108		Continuity.
L109		22.
L110		9.
L111		3.
L112		2.
L113		1.
L114		Continuity.
L115		Continuity.
L201		15.
L202		4.
L203		59.
L204		23.
L205		280.
L206		105.
T301	1–4	4.
	2–5	5.
	3–6	5.
L301		67.
L302		12.
L303		12.
L401	Secondary	480.
	Tickler	53.
T501	2–4	1,700.
	1–3	170.
T601	1–2 or 3–4	5.
	5–6	400.
	6–7	45.
	7–8	50.
T602	1–2 or 3–4	5.
	5–6	Continuity.
	7–8	Continuity.
	9–10	Continuity.
	11–12	Continuity.
L601	1–2	20.
	3–4	20.

79. Signal Substitution Notes

The following general notes apply to signal substitution and signal tracing in the frequency meter.

a. A signal generator is required to develop a signal of the correct frequency and amplitude that is to be substituted in, or traced through, the equipment under test. In certain cases, self-generated signals can be used for this purpose.

b. A method is required to observe, measure, or listen to the output of the circuit that is being tested. This may be by means of an oscilloscope to observe the wave form, a high resistance voltmeter to measure the voltage, or, under certain conditions, a loudspeaker or headset to listen to the signal.

Caution: Do not remove the shield cans or other shielding until the trouble has been traced to a specific area. Do not push parts or wiring out of their normal positions. This may cause broken connections or may alter the operating characteristics of a circuit.

c. When connecting a signal generator to the grid of a tube, be sure that the low resistance output of the signal generator does not short the grid bias voltage (if present) in the circuit under test. It is advisable to connect a low-loss capacitor in series with the output lead (high side) of the signal generator.

d. When the defective stage or circuit is located, disconnect the test equipment and make voltage and resistance measurements to locate the defective part.

80. Signal Substitution in Frequency Meter FR–4/U

Frequency Meter FR–4/U contains three free-running oscillators, a built-in oscilloscope, a tuning meter, and an audio amplifier. In addition to external test equipment, these circuits of the frequency meter may be used for self-testing certain circuits.

a. Localizing Trouble, No Zero-beat Indication Obtained on Any Bands.

(1) If a zero beat cannot be obtained on any band, but the TUNING METER operates normally, the trouble exists either in the indicator subchassis or the proxy oscillator-multiplier subchassis.

(2) To localize between these two subchassis, insert a low-frequency signal (below 500 cycles) into the grid (pin 2) of V501A. This signal may originate in Audio Oscillator TS–382A/U. A sufficient signal may be obtained by

placing a finger on the grid of V501A. In either case, a fairly loud tone should be heard in the headset. If the tone is heard, the trouble is localized to the proxy oscillator-multiplier subchassis. If no tone is heard, the trouble is in the indicator subchassis. For further trouble-shooting information concerning the audio circuits, refer to paragraph 75.

(3) If the trouble is localized to the proxy oscillator-multiplier subchassis, it probably exists in proxy oscillator V101, buffer amplifier V102, or zero mixer V107. Operation of the proxy oscillator may be checked quickly by measuring the grid-leak bias between pins 1 and 7 of V101. If present, the bias indicates operation of the proxy oscillator.

(4) The operation of the proxy oscillator and its buffer amplifier may be checked by the following method:

(*a*) On any band, turn the proxy oscillator dial until the hairline falls directly on any harmonic number.

(*b*) Set the HARMONIC NO. switch to this harmonic number.

(*c*) With the FUNCTION SW. at MEAS. position, there should be horizontal deflection on the cathode-ray tube for proper operation of the proxy oscillator and its buffer amplifier.

(5) If the above test ((4) above) shows the proxy oscillator and buffer amplifier to be operating, the trouble (no zero beat) is probably in the zero mixer stage. Voltage and resistance measurements are required to complete determination of fault (fig. 75).

b. Localizing Trouble, Zero-Beat Indication Obtained on Band 1 Only.

(1) If zero beat is obtained on band 1 only, the trouble is between the output of buffer amplifier V102 and the input to zero mixer V107.

(2) To check for the presence of an input signal to first multiplier V103, check for grid-leak bias between pins 1 and 7. If bias is not present, check capacitor C113 and resistor R115.

(3) To determine if first multiplier V103 has an output, check for grid-leak bias of limiter-amplifier V104 between pins 1 and 7. If no bias is present, check V103 and its associated components.

(4) To check for an output from limiter-amplifier V104, check for grid-leak bias of second multiplier V105 between pins 1 and 7. If no bias is present, check V104 and its associated components.

(5) To check for operation of second multiplier V105, turn the BAND SWITCH to BAND 5 or BAND 6 position. Check for grid-leak bias of third multiplier V106 between pins 1 and 7. If no bias is present, check V105 and its associated components.

(6) To determine if the third multiplier is operating, turn the BAND SWITCH to BAND 7. Check for grid-leak bias of zero mixer V107 between pins 2 and 7. If no bias is present, check V106 and its associated components.

c. Localizing Trouble, No Horizontal Deflection on SCOPE. If no horizontal deflection is obtained in any position of the FUNCTION SW., the trouble may be in any one of three subchassis—the indicator subchassis, the harmonic selector subchassis, or the crystal oscillator-divider subchassis. A procedure consisting of signal tracing and signal substitution will enable the trouble to be localized.

(1) Connect an oscilloscope to the OUTPUT 10 KC jack J318 and observe if the sharp 10-kc pulse is present. If it is, the crystal oscillator-divider subchassis and blocking oscillator V301 are operating. Tune in a harmonic of 10 kc on a low-frequency receiver. This may require connecting the antenna terminal of the receiver to the OUTPUT 10 KC jack.

(2) Assuming that the 10-kc pulse is present, the trouble lies between the harmonic selector and indicator subchassis.

(3) To localize between these two subchassis, insert a signal from the audio oscillator into the grid (pin 7) of horizontal deflection amplifier V504. If horizontal deflection occurs, the

trouble is localized to the harmonic selector subchassis (exclusive of blocking oscillator V301).

(4) Try several harmonic numbers (with appropriate proxy oscillator settings). If horizontal deflection occurs on some but not on all settings, check HARMONIC NO. switch S303.

(5) If horizontal deflection does not occur on any setting of S303, insert a 15- to 20-kc signal into the grid (pin 1) of the 15–20 kc amplifier (V305); use the audio oscillator. If horizontal deflection does not occur, check V305 and its associated components.

(6) If horizontal deflection has been obtained in the step given in (5) above, continue with signal substitution by injecting a 15- to 20-kc signal into the grid (pin 1) of measure mixer V304. If horizontal deflection is not now obtained, check V304 and its associated components, including the 15–20 kc filter FL301.

(7) If horizontal deflection has been obtained in the step given in (6) above, inject the 15- to 20-kc signal into the grid (pin 3) of harmonic amplifier V303A. If horizontal deflection is not now obtained, check amplifier V303A and its associated components.

(8) If horizontal deflection has been obtained in the step given in (7) above, the trouble must lie in the pulse-shaper amplifier stage V302 or its associated components. This follows since it is known that there is a 10-kc output from V301.

(9) If no 10-kc pulse can be measured at OUTPUT 10 KC jack J318, the trouble may be either in blocking oscillator V301 or in the crystal oscillator-divider subchassis.

(10) To check for operation of crystal oscillator V202 (1,250 kc) and its buffer amplifier V203, connect the antenna terminal of a suitable receiver to OUTPUT 1250 KC jack J219 and tune in the crystal oscillator frequency.

(11) If an output is observed in the step given in (10) above, the trouble is between the output of buffer amplifier V203 and the output of blocking oscillator V301.

(12) To check the operation of the blocking oscillator, insert a 10-kc signal from the audio oscillator into the grid (pin 3) of trigger amplifier V301A. Monitor the output of the blocking oscillator with the oscilloscope at the OUTPUT 10 KC jack. If no output appears, check V301 and its associated components.

(13) If, in the step given in (12) above, an output is obtained from the blocking oscillator and an output has been observed from the crystal oscillator, the trouble lies between first frequency divider V203 and 10-kc amplifier V207.

(14) With an oscilloscope connected to the OUTPUT 10 KC jack as an indicator, apply a 10-kc signal from the audio oscillator to the grid (pin 7) of V207B. If no output is observed on the oscilloscope, check V207 and its associated components.

(15) If an output is observed in the step given in (14) above, the 10-kc amplifier is functioning. To check the operation of third frequency divider V206B and V207A, inject a 50-kc signal from RF Signal Generator AN/URM–25B into the grid (pin 7) of V206B. Leave the oscilloscope connected as instructed in (14) above. If no output is observed, check V206 and V207 and the components associated with V206B and V207A.

(16) If an output is observed in the step given in (15) above, adjust the signal generator to 250 kc and feed the signal into the grid (pin 7) of second frequency divider V205B and V206A. If no output is observed on the oscilloscope, check V205 and V206 and the components associated with V205B and V206A.

(17) If, in the step given in (16) above, an output is observed from the OUTPUT 10 KC jack, check cathode follower V205A by injecting a 250-kc signal into its grid (pin 2). If no output appears on the oscilloscope, check V205 and its associated components.

(18) If an output appears in the step given in (17) above and the crystal oscillator is known to be operating (from OUTPUT 1250 KC), the fault lies with first frequency divider V204. Check V204 and its associated components.

(19) If there is no output from the OUTPUT 1250 KC jack, check for operation of the crystal oscillator by measuring the grid-leak bias of V202 between pins 1 and 7. If no bias is present, the oscillator is not working. In this case, check V202 and its associated components, including crystal Y201.

(20) If, in the step given in (19) above, bias is present but there is no output from the OUTPUT 10 KC jack, check V203 and its associated components.

Section II. REPAIRS

81. Replacement of Parts

Note. Many of the components used in the frequency meter have critical tolerances or characteristics. Safe practice indicates the replacement of a damaged component with the *exact* part. This is particularly true of all coils and all fixed capacitors in the tuned circuits—proxy oscillator, frequency multiplier, frequency divider, preselector, crystal oscillator, interpolation oscillator, and tuned circuit of the harmonic selector. If components with slightly different values and characteristics are used in these circuits, the calibration and/or operation of the frequency meter will be affected.

a. Most of the components of Frequency Meter FR–4/U are readily accessible and are easily replaced if found faulty.

(1) All chassis are available by removal of the dust cover. To remove the interpolation oscillator subchassis from the frame, open the four slide fasteners on the base of the junction box; disconnect all cables from the junction box; lift the junction box from the frame; remove the CAL. ADJ. knob that protrudes through the front panels; remove the two screws that hold the chassis to the front panel and the two in the rear that fasten it to the frame; and slide the interpolation oscillator subchassis directly to the rear through the bridge in the frame. To remove all other subchassis, disconnect all cables at the jacks or plugs, remove any knobs that protrude through the front panel, and withdraw the screws that hold the subchassis to the front panel and the rear of the frame.

(2) Except for self-mounted components, all components and removable subassemblies are mounted securely to the chassis with hexagonal nuts and slot-head screws.

b. If any wafer of switch S101 requires replacement, carefully mark the wires connected to the wafer with tags to avoid misconnections when the new switch is installed. Follow this practice whenever replacement requires the disconnection of a number of wires.

c. Access to all components is shown in the component location illustrations (figs. 57 through 75). To remove the crystal and the unit oven from the crystal oscillator-divider subchassis (fig. 60), remove the screw that secures the strap to the chassis, lift the strap, and slide out the unit. To remove the crystal, first remove the two screws that hold the crystal oven cover to the base. Slide the base out of the crystal oven cover and remove the blanket. Remove the two screws from the cover plate and remove the cover plate; be careful not to disturb the wiring. Remove the crystal plastic cover and then remove the crystal.

d. All knobs are secured to their shafts by Allen-head setscrews. The shafts are either flatted or recessed to fix the position of the knobs on the shafts. When replacing a knob, be sure the setscrew is secured in its recess or flat.

82. Removal and Replacement of Capacitor C401 and INTERPOLATION OSC. Dials

Caution: Do not remove or replace capacitor C401 unless the necessary calibration equipment is available.

a. Removal.

(1) Remove the interpolation oscillator subchassis from the frame.

(2) Remove the three screws that hold

the dial knob, and remove the dial knob.

(3) Remove the four screws that hold the outer dial ring, and remove the dial ring.

(4) Loosen the two setscrews in the dial hub, and take off the complete dial assembly.

(5) Remove the cover of the interpolation oscillator subchassis by removing the holding screws.

(6) Unsolder the connections to the rotor and stator terminals of C401.

(7) Remove the three screws from the bottom of C401 and lift out C401.

Note. Be careful at this point to prevent damage to glass capacitor C413.

(8) Remove the drum dial from C401 by loosening the Allen-head setscrews.

b. Replacement.

(1) Place drum dial on new capacitor C401, but do not tighten setscrews.

(2) Mount new capacitor C401 and secure with three screws at the bottom.

(3) Resolder connections to the rotor and stator of C401; be careful to make perfect solder joints.

(4) Set C401 to maximum capacity position with edges of rotor and stator plates parallel.

(5) Rotate the drum dial so that the zero division coincides with the hairline. Center the drum dial lengthwise on the capacitor shaft so that the figures are in the middle of the window. Tighten the two setscrews.

(6) Replace the disk dial assembly, but do not tighten the setscrews.

(7) Install the dial ring by means of four screws so that the ring is centralized about the disk dial.

(8) Check to see that the plates of C401 are still at maximum capacity and parallel. Aline the zero division of disk dial with the arrow on the dial ring. Tighten the two setscrews in the disk dial hub.

(9) Rotate the disk dial and check for binding between the disk dial and the dial ring. Readjust the dial ring for proper clearance as required.

(10) Replace the dial knob by means of the three screws.

83. Removal and Replacement of PROXY. OSC. Dial and Gear Train

Note. Because of mated, spring-loaded gears used with critical tolerance, the PROXY. OSC. dial and gear train assembly is procured and replaced as an assembly.

a. Removal.

(1) Remove the proxy oscillator-multiplier subchassis from the frame.

(2) Disconnect all wiring (as required) and tag each lead as it is removed.

(3) Loosen the setscrews that secure the adjustable coupling (fig. 58) to the gear train and capacitor C101. Slide the adjustable coupling free of the gear train shaft.

(4) Remove the bottom cover by withdrawing two screws on each side and eight on the bottom of the chassis.

(5) Use needle-nosed pliers or a thin open-end wrench and remove the three nuts that secure the gear train to the chassis. These are accessible between the two plates of the gear train.

(6) Remove the gear train.

b. Replacement.

(1) Secure the gear train to the chassis with three nuts.

(2) Install the bottom cover.

(3) Connect all the wiring.

(4) Connect capacitor C101 to the gear train shaft by means of the adjustable control, and aline the proxy oscillator as described in paragraph 88.

84. Refinishing

Instructions for refinishing exteriors of badly marred panels are given in TM 9–2851, Painting Instructions for Field Use.

85. Dial Adjustments

a. The PROXY. OSC. dial is keyed to a shaft of the associated gear train by means of flats on successive shoulders. Adjustment in the relationship of gear train and capacitor C101 is obtained during the alinement of the proxy oscillator (par. 88).

b. The INTERPOLATION OSC. dials are positioned on their respective shafts by setscrews and recesses in the shafts. When replacing these dials, be sure that the setscrews engage the shafts exactly at the prepared recess. No other adjustment is required.

Section III. CALIBRATION AND ALINEMENT

86. Test Equipment Required for Calibration and Alinement

The following test equipment is required for calibration and alinement of Frequency Meter FR–4/U.

Test equipment	Technical manual
Radio Receiver R–395/PRD–1	TM 11–677
Oscilloscope OS–8A/U	TM 11–1214
Frequency Calibrator Meter Set AN/URM–18.	
RF Signal Generator AN/URM–25B	TM 11–5551B
Electronic Multimeter TS–505/U	TM 11–5511
Frequency Meter FR–67/U	TM 11–2698
Headset HS–33	TM 11–2619

87. Calibration of Interpolation Oscillator

a. If sealed coil L402 in the interpolation oscillator subchassis is replaced, it will be necessary to recalibrate the interpolation oscillator and prepare new entries in the calibration book.

b. Information and equipment for calibration will be made available to the organizations responsible for such work.

88. Alinement of Proxy Oscillator

a. Before alinement of the proxy oscillator can be started, the two dial stops located between the two plates of the gear train (fig. 58) must be backed off to allow the tuning capacitor to travel its full range. These are No. 6 Allen-head screws.

b. Turn the tuning capacitor C101 to its maximum capacity position; be careful not to overload the antibacklash springs in the gears. A short index line should be under the hairline. If it is not, loosen the locknut and turn the fine adjustment on the coupling between the variable capacitor and the gear box for proper indexing. After retightening the locknut, check the adjustment several times by rotating the variable capacitor toward minimum and back to maximum capacitance position, and observing the location of the index line. Rotate the variable capacitor until the hf stop line appears under the hairline; reset the second gear train dial stop.

c. In the minimum capacity position of the tuning capacitor, the proxy oscillator frequency should be 256 kc. This frequency may be measured with Frequency Calibrator-Meter Set AN/URM–18. To measure the frequency, set the BAND switch to band 1 and the FUNCTION SW. to MEAS. Connect the rf cable from the SIGNAL OUTPUT jack to the frequency calibrator. Adjust capacitor C104 to provide 256 kc.

Note. If the frequency calibrator is not available, the following method may be used: Tune in WWV on a receiver (preferably at 2.5 mc). Set the proxy oscillator dial to read 250 kc. A small line on the PROXY. OSC. dial following harmonic No. 23 indicates 250 kc. Couple a signal from the SIGNAL OUTPUT jack of the frequency meter to the antenna circuit of the receiver. Adjust capacitor C104 to provide zero beat.

d. Check the proxy oscillator frequency at the scale line corresponding to 250 kc. Turn the FUNCTION SW. to MEAS. and BAND SWITCH to BAND 1. Couple the 10-kc pulse from the harmonic selector subchassis at J318 to the input of the preselector at J106. If required, adjust trimmer capacitor C104 to secure a zero beat in the headset and in the blinker. Tune from 200 kc to 100 kc and observe the location of zero beats with reference to the dial calibration. The hairline should fall approximately centered at each dial calibration.

e. After the proxy oscillator has been alined, reset the two dial stops so that the dial motion is checked approximately halfway between the end calibration figures and the limit line on both ends of the dial.

89. Alinement of Preselector Amplifier and Frequency Multipliers

a. Preliminary Alinement of Preselector Amplifier.

(1) Connect a standard signal generator with a range of 100 kc to 20 mc to the SIGNAL INPUT jack. Set the FUNCTION SW. to MEAS. Turn the BAND SWITCH to BAND 1 position and the tuning dial to 250 kc. Set the standard signal generator to 250 kc. Adjust the trimmer capacitor C148 for maximum swing of the TUNING METER. Keep the INPUT ATTENUATOR knob and standard signal generator adjusted so that the needle does not go beyond approximately half scale. Next set the tuning dial and

standard signal generator to 100 kc. Adjust the slug of L109 for maximum swing on the TUNING METER; keep the meter operating in the center of its range by adjustment of the INPUT ATTENUATOR of standard signal generator.

Note. The alinement points of the preselector amplifier are accessible through an opening in the rear of the proxy oscillator-multiplier subchassis (fig. 90). The numerals beneath the openings refer to the band numbers affected by the alinement points.

(2) Continue the procedure as given in (1) above for all the other bands. Table I gives the necessary information for adjusting the preselector amplifier on all bands.

b. Preliminary Alinement of Frequency Multipliers.

(1) Frequency multiplier coils are adjusted for bands 2 through 7. Connect a headset and an output meter simultaneously to PHONES jack. This can be done by removing the insulating jacket from the headset plug and connecting the output meter to the headset plug contacts. Maintain the standard signal generator connection as for alinement of the preselector amplifier (*a* above).

(2) Aline band 2 frequency multiplier as follows:

(*a*) Set the BAND SWITCH to BAND 2 and the FUNCTION SW. to MEAS.

Table I. Alinement Data for Preselector Amplifier (fig. 90)

Band No.	Trimmer capacitor	Trim at—	Coil	Adjust slug at—
1	C148	250 kc	L109	100 kc
2	C149	500 kc	L110	250 kc
3	C150	1.25 mc.	L111	500 kc
4	C151	2.5 mc	L112	1.25 mc
5	C152	5.0 mc	L113	2.5 mc
6	C153	10.0 mc	L114	5.0 mc
7	C154	20.0 mc	L115	10.0 mc

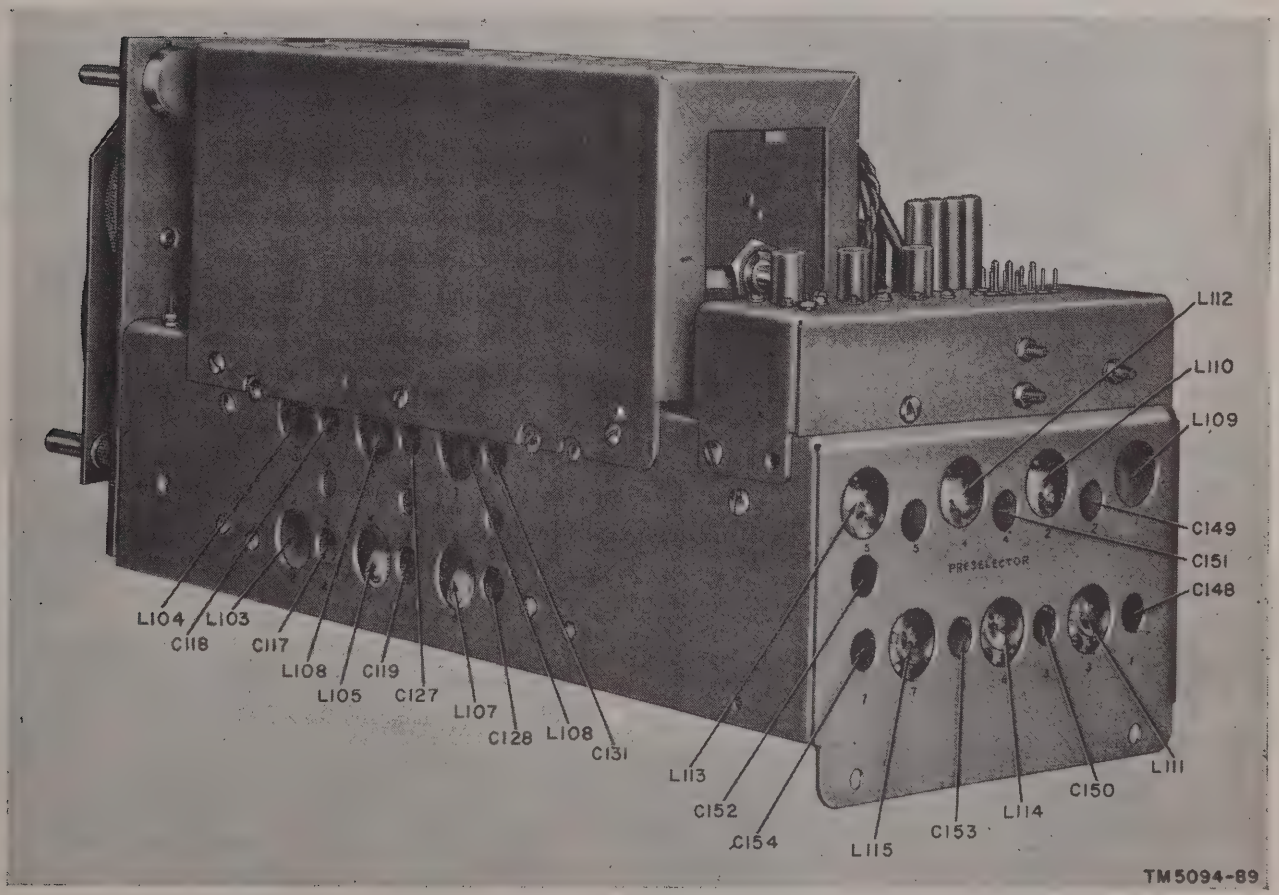


Figure 90. Proxy oscillator-multiplier subchassis, location of alinement points.

(*b*) Set the standard signal generator to the trim frequency of 250 kc (table II) and see that the TUNING METER is at midscale.

(*c*) Adjust the PROXY. OSC. dial at 250 kc to obtain an audio frequency close to zero beat. Adjust trimmer capacitor C117 for maximum indication on the output meter; keep the standard signal generator output adjusted so that the output meter peaks near 2 volts rms.

(*d*) Set the standard signal generator and the proxy oscillator tuning dial to 100 kc.

(*e*) Adjust proxy oscillator tuning dial for an audio frequency close to zero beat.

(*f*) Adjust the slug of coil L103 for a peak reading on the output meter. Keep the peak near 2 volts rms.

Note. The alinement points of the frequency multipliers are accessible through openings in the side of the proxy oscillator-multiplier subchassis (fig. 90). The numerals beside the openings refer to the band numbers affected by the alinement points.

(*g*) The same procedure is followed when alining the other multiplier circuits. The required information appears in table II.

Note. Be particularly careful with the adjustment of the band 4 multiplier because the operation of the higher bands depends on the operation of band 4.

Table II. Alinement Data for Frequency Multipliers (fig. 90)

Band No.	Trimmer capacitor	Trim at—	Coil	Adjust slug at—
2	C117	500 kc	L103	250 kc
3	C118	1.25 mc	L104	500 kc
4	C119	2.5 mc	L105	1.25 mc
5	C127	5.0 mc	L106	2.5 mc
6	C128	10.0 mc	L107	5.0 mc
7	C131	20.0 mc	L108	10.0 mc

c. Final Alinement of Preselector Amplifier.

(1) Repeat the adjustments of the preselector amplifier tuned circuits as described in *a* above. This time, adjust the proxy oscillator tuning dial for exact zero beat in the headset on each alinement frequency.

(2) Readjust the trimmer capacitor and slugs for maximum deflection of the TUNING METER. Keep the standard signal generator adjusted so that the TUNING METER does not read beyond midscale.

d. Final Alinement of Frequency Multipliers. Recheck the alinement of the frequency multipliers. Follow the procedure given in *b* above.

90. Alinement of Crystal Oscillator and Frequency Dividers

a. The crystal oscillator frequency may be checked and corrected with the aid of a frequency counter such as Frequency Calibrator Meter Set AN/URM–18 or its equivalent. To measure the crystal oscillator frequency, couple the output from the OUTPUT 1250 KC jack to the input receptacle of the frequency counter. Adjust trimmer capacitor C206 for an exact output signal of 1,250 kc.

b. To aline the frequency dividers, proceed as follows:

(1) Remove the crystal from the subchassis.

(2) Set a standard signal generator (RF Signal Generator AN/URM–25B or its equivalent) for an output at 10.7 kc and connect this output to pin 7 of V206.

(3) Connect the vtvm (ac) to pin 2 of V207 and ground.

(4) Adjust L205 for maximum output.

Note. The alinement points of the frequency dividers are accessible through openings in the sides of the network cans on the crystal oscillator-divider subchassis (fig. 60). The openings are identified by stenciled symbol numbers indicating the accessible component.

Table III. Alinement Data for Frequency Dividers

Set signal generator at—	Signal generator input to—	Vtvm to—	Adjust for maximum
10.7 kc	V206, pin 7	V207, pin 2	L205
42.75 kc	V207, pin 2	V206, pin 8	L206
57 kc	V205, pin 7	V206, pin 2	L203
214 kc	V206, pin 2	V205, pin 8	L204
242 kc	V204, pin 2	V205, pin 2	C227
975 kc	V204, pin 7	V204, pin 2	C230

(5) The procedure for alining the remainder of the frequency divider circuits is the same as above. Refer to

table III for the necessary information. Aline in the order given in the table, and repeat the procedure until no further improvement is noted.

91. Alinement of Harmonic Selector

a. Preliminary Alinement.

(1) Disconnect plug P308 from the crystal oscillator-divider subchassis. Connect the high side of the standard signal generator through a .01 microfarad capacitor to the junction of L301 and C393 on the terminal board. Connect the ground side of the standard signal generator to the ground terminal on the terminal board.

(2) Set the HARMONIC NO. switch to position 9 (90 kc) and the FUNCTION SW. to CAL. Connect a test oscilloscope to jack J314 after removing plug P514.

(3) Set the standard signal generator to 90 kc at an output of approximately 1 volt.

(4) Adjust trimmer capacitors C301 and C302 (marked 9 on chassis) for maximum amplitude as displayed on the oscilloscope.

Note. The alinement points for the harmonic selector are accessible through openings in the top of the harmonic selector subchassis (fig. 63). The numerals beside the openings identify the HARMONIC NO. switch setting adjusted by the capacitors beneath.

(5) Repeat the above procedure for harmonics 10 through 26, following the information given in table IV.

Table IV. Alinement Data for Harmonic Selector

Harmonic No. switch set at—	Signal generator set at (kc)—	Adjust capacitors for maximum
9	90	C301, C302
10	100	C307, C308
11	110	C313, C314
12	120	C317, C318
13	130	C321, C322
14	140	C325, C326
15	150	C329, C330
16	160	C335, C336
17	170	C341, C342
18	180	C347, C348
19	190	C351, C352
20	200	C355, C356
21	210	C361, C362
22	220	C365, C366
23	230	C369, C370
24	240	C373, C374
25	250	C379, C380
26	260	C385, C386

b. Final Alinement.

(1) Connect plug P308 to the crystal oscillator-divider subchassis and disconnect the standard signal generator.

(2) Set the HARMONIC NO. switch to 9 and readjust capacitors C301 and C303 for maximum amplitude on the test oscilloscope. In the same way, set the HARMONIC NO. switch to each remaining harmonic number and readjust the proper capacitors (indicated in table IV) for maximum amplitude on the oscilloscope.

Section IV. FINAL TESTING

92. General

This section is intended as a guide to be used in determining the quality of a repaired Frequency Meter FR–4/U. The minimum test requirements given in paragraphs 93 through 98 may be performed by maintenance personnel with adequate test equipment and the necessary skills. Repaired equipment meeting these requirements will furnish uniformly satisfactory operation.

93. Test Equipment Required for Final Testing

a. The test equipment listed in paragraph 86 is required for final testing.

b. In addition, the following items of test equipment are required:

Test equipment	Technical manual
Audio Oscillator TS–382A/U	TM 11–2684A
Electronic Multimeter ME–6A/U	TM 11–5549

94. Final Testing of Indicator Subchassis

Final testing of the indicator subchassis involves checking the performance of the audio amplifier (including expansion function) and the oscilloscope.

a. To check the audio amplifier section, proceed as follows:

(1) Disconnect plug P504 from jack J104, which is located on the proxy oscillator-multiplier subchassis.
(2) Connect a 600-ohm resistor to PHONES jack J310.
(3) Connect the audio oscillator to the grid (pin 2) of V501 and ground. Set the audio oscillator to 400 cycles and an output voltage of .04 volt. The output voltage may be measured with Electronic Multimeter ME–6A/U.
(4) Adjust expansion control R505 for minimum output voltage across the 600-ohm resistor. This voltage may be measured with the multimeter. The minimum output voltage should be in the order of .008 volt. This output voltage is one-fifth of the input voltage, and it shows the action of the bucking amplifier.
(5) Raise the input voltage to .16 volt. Measure the output voltage (across 600-ohm resistor) which should be approximately .72 volt. This check shows the expansion operation because a gain of 4.5 is now evident.
(6) Check the operation of the audio section by further voltage measurements (at 400 cycles) as indicated in table V.

Table V. Final Test of Audio Section, Voltage Measurements

Voltage input to V501A, pin 2	Voltage output across 600-ohm resistor
0.01	0.0065
0.02	.0067
0.04	.008
0.08	.012
0.16	.72
0.32	1.45
0.64	2.85
1.28	5.3

b. To check the sensitivity of the vertical deflection amplifier, proceed as follows:
(1) Disconnect plug P512 from jack J412 located on the interpolation oscillator subchassis.
(2) Connect the audio oscillator to plug P512.
(3) Set the audio oscillator to 17.5 kc and adjust its output control to obtain a 1-inch vertical deflection.
(4) Measure the output of the audio oscillator with the multimeter.
(5) The input voltage for 1-inch vertical deflection should be approximately .97 volt.

c. To check the sensitivity of the horizontal deflection amplifier, proceed as follows:
(1) Disconnect plug P514 from jack J314 located on the harmonic selector subchassis.
(2) Connect RF Signal Generator AN/URM–25B to plug P514.
(3) Set the signal generator to 175 kc and adjust the output control to obtain a horizontal deflection of 1 inch with the HOR. GAIN control in maximum clockwise position.
(4) Determine the output of the signal generator according to the built-in voltage calibration.
(5) The input voltage (signal generator output) for 1-inch horizontal deflection should be approximately .82 volt.

95. Final Testing of Proxy Oscillator-Multiplier Subchassis

a. The overall performance of the proxy oscillator-multiplier subchassis may be checked by measuring the audio output of the zero mixer V107 on all bands. On each band, the audio output should be checked at both ends and the center of the frequency range. Proceed as follows:
(1) Set the BAND SWITCH to BAND 1 and the INPUT ATTENUATOR to maximum clockwise position.
(2) Connect RF Signal Generator AN/URM–25B to the SIGNAL INPUT jack. Set the signal generator frequency to 100 kc and the output at 10,000 microvolts (uv).
(3) Disconnect plug P504 from jack J104.
(4) Connect the multimeter to jack J104.
(5) Turn the proxy oscillator dial to 100 kc and adjust the dial for maximum deflection of the output meter. The maximum reading should be at least .3 volt on all bands and may be 1 volt or more.
(6) Repeat the above procedures at frequencies of 175 kc and 250 kc for

band 1; set the signal generator to the appropriate frequency in each case.

(7) Repeat the above procedures for each of the remaining bands, and check the output at each end and at the center of each band as shown in table VI. At all frequencies checked, set the signal generator to the indicated frequency and adjust the proxy oscillator dial for maximum output meter indication.

b. To further test the proxy oscillator-multiplier subchassis, measure the rf output voltage on all bands as follows:

(1) Connect a 51-ohm resistor across the SIGNAL OUTPUT jack. The output across this resistor is fed to the antenna input circuit of Radio Receiver R–395/PRD–1.

(2) Set the BAND SWITCH to BAND 1 and the proxy oscillator dial to 100 kc.

(3) Set the FUNCTION SW. to MEAS.

(4) Tune the receiver for maximum deflection of the S meter and note the S meter reading.

(5) Disconnect the frequency meter from the receiver.

(6) Connect RF Signal Generator AN/URM–25B to the antenna input circuit of the receiver and set the signal generator to 100 kc.

(7) Tune the signal generator carefully for a peak reading on the S meter.

(8) Adjust the output of the signal generator to obtain the same reading on the S meter as that noted in (4) above.

(9) Determine the output of the signal generator according to its built-in voltage calibration.

(10) The output voltage at 100 kc and at all other frequencies should be at least 100 uv. The output voltage will generally be lowest on band 1 and highest on band 7 where it may reach 10,000 uv.

(11) Check band 1 at 175 kc and 250 kc. For frequencies on each of the remaining bands, see table VI.

Table VI. Final Test Check Frequencies

Band	Frequencies (MC)	Band	Frequencies (MC)
7	20	4	1.25
7	15	3	1.25
7	10	3	.75
6	10	3	.5
6	7.5	2	.5
6	5	2	.375
5	5	2	.250
5	3.75	1	.250
5	2.5	1	.175
4	2.5	1	.100
4	1.9		

96. Final Testing of Crystal Oscillator-Divider Subchassis

a. Check the output of the crystal oscillator as follows:

(1) Connect a 51-ohm resistor across the OUTPUT 1250 KC jack and feed the output to Radio Receiver R–395/PRD–1.

(2) Tune the receiver for maximum deflection on the S meter and note the reading of the S meter.

(3) Disconnect the frequency meter from the receiver.

(4) Connect the rf signal generator to the receiver and tune the signal generator for maximum deflection on the S meter.

(5) Adjust the signal generator output to obtain a reading on the S meter which is the same as that noted in (2) above.

(6) Determine the output voltage of the signal generator by means of the built-in voltage calibration.

(7) The output voltage should be in the order of .02 volt.

b. Check the output voltage of 10-kc amplifier V207B as follows:

(1) Disconnect plug P308 from jack J208.

(2) Connect a multimeter to jack J208. The 10-kc output voltage should be approximately 20 volts, peak to peak.

c. Check for nonfree running of the frequency dividers as follows:

(1) Retain connections as described in *b* above.

(2) Unplug oscillator tube V202. The output should drop to zero.

d. Check the output frequency at J208 with the frequency calibrator. The frequency should be 10 kc within .00012 percent.

97. Final Testing of Interpolation Oscillator Subchassis

a. Check to see that 20,000 cycles per second occur at dial division 4,500. This check may be made as described in paragraph 88*b*.

b. Test each crystal check point given in the calibration book to see if the required PATTERN RATIO can be obtained by adjusting the CAL. ADJ. knob.

c. Check the output signal voltage from V402 as follows:

(1) Disconnect plug P512 from jack J412.
(2) Connect the multimeter to jack J412.
(3) Measure the signal output voltage. This should be 2.5 volts ±.5 volt, peak to peak.

98. Final Testing of Harmonic Selector Subchassis

a. Check the output amplitude on all harmonics as follows:

(1) Turn the FUNCTION SW. to CAL. position.
(2) Disconnect plug P514 from jack J314.
(3) Connect the oscilloscope to jack J314.
(4) Check the output voltage on all harmonics by calibrating the oscilloscope. The amplitude of the various harmonics should not vary much in excess of 10 per cent. The average amplitude should be about 16 volts.

b. Check the frequency of all harmonics as follows:

(1) Follow *a* (1) and (2) above.
(2) Connect the frequency calibrator to jack J314.
(3) Starting with the 9th harmonic (90 kc), check the frequency of the 9th to 26th harmonics by turning the HARMONIC NO. switch. Read the resultant frequencies on the frequency calibrator. These should be accurate within .00012 percent.

c. Check the output voltage from the 15–20 kc amplifier, V305, as follows:

(1) Turn the FUNCTION SW. to MEAS.
(2) Disconnect plug P514 from jack J314 and connect the vtvm to jack J314.
(3) Set the BAND SWITCH to any band (except BAND 1) and adjust the TUNING control until the hairline of the proxy oscillator dial is directly over harmonic No. 18.
(4) Set the HARMONIC NO. switch to the 18th harmonic position.
(5) The vtvm should read 7 volts, peak to peak.

99. Final Testing of Frequency Meter FR–4/U

After final testing of the individual subchassis, the overall performance of the frequency meter must be checked as follows:

a. Audio Output Check. The audio output of the frequency meter is required to be a minimum of 2 mw in a resistive load of 600 ohms with an input signal amplitude of 10,000 uv. This check is made as follows:

(1) Connect the vtvm to the PHONES jack across a 600-ohm resistor.
(2) Connect the signal generator to the SIGNAL INPUT jack. Set the generator output to 10,000 uv and the generator frequency to 100 kc.
(3) Set the FUNCTION SW. to MEAS.
(4) Set the BAND SWITCH to BAND 1.
(5) The minimum rms voltage reading on all bands should be about 1.1 volts. However, it may be three or four times this amount.
(6) Check the output voltage at 175 kc and 250 kc on band 1. Check the output voltage at the extremes and center of all other bands. The requirements of (5) above should be met on all frequencies.

b. Spurious Response Check. The spurious responses as heard in the headphones are required to be at least 30 decibels (db) (voltage) below the desired response. Check the spurious responses as follows:

(1) Connect the signal generator to the SIGNAL INPUT jack. Set the output for 100,000 uv and the frequency to 100 kc.
(2) Plug the headset into the PHONES jack and connect the vtvm across the headset terminals.

(3) Set the BAND SWITCH to BAND 1.
(4) Set the FUNCTION SW. to MEAS.
(5) Set the proxy oscillator dial to 100 kc and adjust the tuning control for a maximum reading in the green area of the TUNING METER. Adjust the INPUT ATTENUATOR until a peak can be obtained on the TUNING METER as the PROXY. OSC. dial is turned through 100 kc. Read the vtvm.
(6) Record this maximum reading (which may be approximately 4 volts).
(7) Turn the TUNING control slowly over the range of band 1 and record the voltages of any spurious beats. (A beat may be heard at a harmonic of the signal generator frequency, in this case at 200 kc. This beat should not be considered as a spurious response.)
(8) Record the amplitude of all spurious beats. Then take the highest amplitude spurious voltage and determine its ratio to the desired beat voltage. Convert this ratio to voltage db.
(9) The db calculated in (8) above should be 30 or greater.
(10) Repeat the procedures in (1) through (9) above on bands 2 through 7 covering the entire range on each band. On all bands, the spurious responses should be down at least 30 db.

c. Accuracy Check. The accuracy of the frequency meter on any range is required to be .001 percent. When checking the accuracy, frequency measuring equipment with an accuracy of at least .0001 percent must be used. Accuracy checks may be made with the test setup shown in the block diagram (fig. 91). The procedure is to measure the frequency of the signal generator with both the frequency meter and the frequency calibrator. The reading of the frequency meter is then compared with that of the frequency calibrator, which is used as the measuring standard. The detailed accuracy testing procedure is as follows:

(1) Connect a tee adapter to the SIGNAL INPUT jack.
(2) To this tee adapter, connect the output of the signal generator and the input to the frequency calibrator.
(3) If available, connect an external 100-kc crystal frequency standard to the frequency calibrator.
(4) Set the frequency calibrator for a 10-second count and for manual operation.
(5) Set the BAND SWITCH to BAND 1.
(6) Set the signal generator to approximately 100 kc and for 2 volts output.
(7) Use the normal measuring procedure and measure the frequency of the signal generator with Frequency Meter FR–4/U. Before making the final adjustment of the interpolation oscillator dial, check the zero beat to see if it has drifted.
(8) As the final adjustment of the interpolation oscillator dial is being made, press the manual operating button on the frequency calibrator so that both readings are made simultaneously.
(9) Determine the frequency of the signal generator by means of the frequency meter.
(10) Use the frequency calibrator as a standard and compare the two readings. Frequency Meter FR–4/U reading should not deviate from the frequency calibrator reading by more than .001 percent.
(11) Repeat the procedures described above at 175 kc and 250 kc on band 1 and also at the extremes and center of the frequency range of all remaining bands. In all cases, the frequency meter should be accurate within .001 percent.

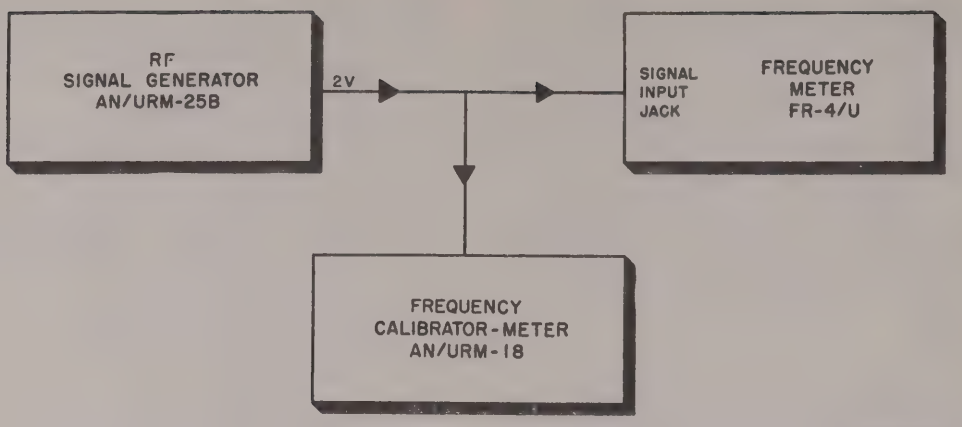


Figure 91. Final accuracy check setup, simplified block diagram.

CHAPTER 6

SHIPMENT AND LIMITED STORAGE AND DEMOLITION TO PREVENT ENEMY USE

Section I. SHIPMENT AND LIMITED STORAGE

100. Disassembly

The following instructions are recommended as a general guide for preparing the frequency meter for transportation and storage.

a. Disconnect the power cable from the power source and stow it on the shelf below the dust cover at the rear of the frequency meter (fig. 8).

b. Close the calibration book and drawer.

c. Loosen the locking knobs and swing the tilt plates upward until detents hold them in a vertical position (fig. 4).

d. Disconnect the rf cable. If the adapter has been used, return it to its clamp on the front panel.

e. Check the equipment to be packed against the table of components (par. 6).

Note. The frequency meter may be stored in its transit case for limited periods.

101. Repacking for Shipment or Limited Storage

Reverse the procedures outlined in paragraph 10 for repacking Frequency Meter AN/URM–79 or Frequency Meter AN/URM–82. Figure 6 illustrates the method of repacking the AN/URM–79. Figure 7 illustrates the method of repacking the AN/URM–82.

Section II. DEMOLITION OF MATERIEL TO PREVENT ENEMY USE

102. General

The demolition procedures given in paragraph 103 will be used to prevent the enemy from using or salvaging this equipment. Demolition of the equipment will be accomplished only upon the order of the commander.

103. Methods of Destruction

a. Smash. Smash the controls, tubes, coils, switches, capacitors, transformers, and meter; use sledges, axes, handaxes, pickaxes, hammers, crowbars, or heavy tools.

b. Cut. Cut the rf cable and the power cord; use axes, handaxes, or machetes.

c. Burn. Burn cords and technical manuals; use gasoline, kerosene, oil, flame throwers, or incendiary grenades.

d. Bend. Bend panel and cabinet.

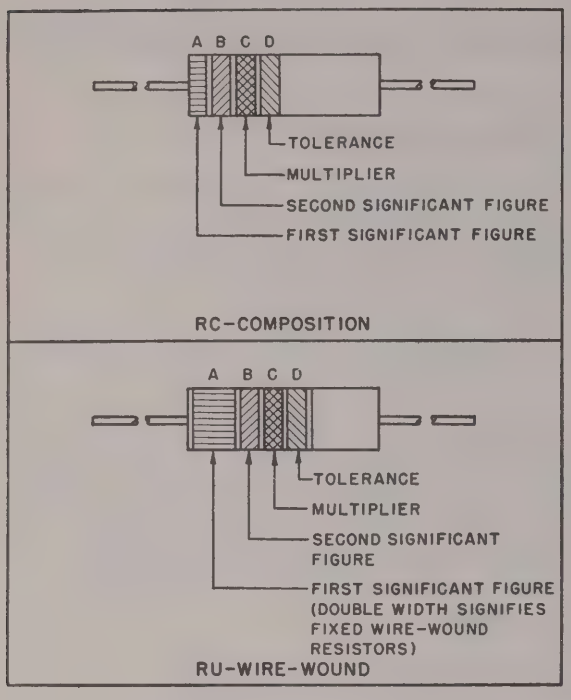
e. Explosives. If explosives are necessary, use firearms, grenades, or TNT.

f. Disposal. Bury or scatter the destroyed parts in slit trenches or fox holes, or throw them into streams.

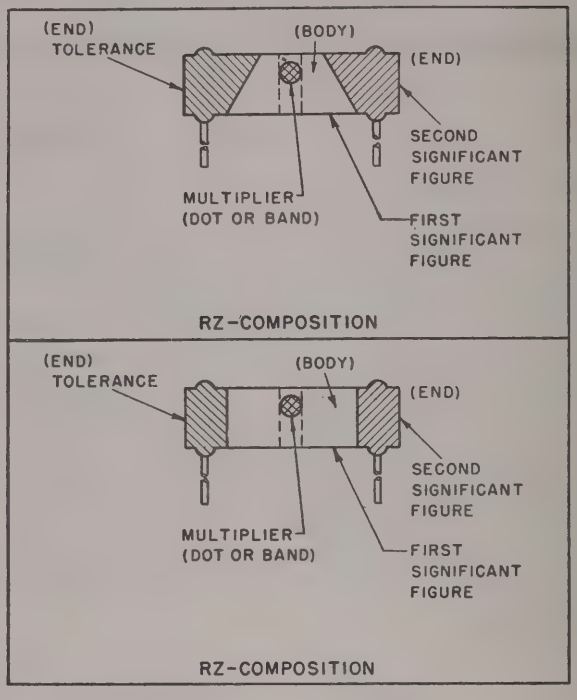
g. Destroy. Destroy everything.

RESISTOR COLOR CODE MARKING
(MIL-STD RESISTORS)

AXIAL-LEAD RESISTORS (INSULATED)



RADIAL-LEAD RESISTORS (UNINSULATED)



RESISTOR COLOR CODE

BAND A OR BODY*		BAND B OR END*		BAND C OR DOT OR BAND*		BAND D OR END*	
COLOR	FIRST SIGNIFICANT FIGURE	COLOR	SECOND SIGNIFICANT FIGURE	COLOR	MULTIPLIER	COLOR	RESISTANCE TOLERANCE (PERCENT)
BLACK	0	BLACK	0	BLACK	1	BODY	± 20
BROWN	1	BROWN	1	BROWN	10	SILVER	± 10
RED	2	RED	2	RED	100	GOLD	± 5
ORANGE	3	ORANGE	3	ORANGE	1,000		
YELLOW	4	YELLOW	4	YELLOW	10,000		
GREEN	5	GREEN	5	GREEN	100,000		
BLUE	6	BLUE	6	BLUE	1,000,000		
PURPLE (VIOLET)	7	PURPLE (VIOLET)	7				
GRAY	8	GRAY	8	GOLD	0.1		
WHITE	9	WHITE	9	SILVER	0.01		

*FOR WIRE-WOUND-TYPE RESISTORS, BAND A SHALL BE DOUBLE-WIDTH. WHEN BODY COLOR IS THE SAME AS THE DOT (OR BAND) OR END COLOR, THE COLORS ARE DIFFERENTIATED BY SHADE, GLOSS, OR OTHER MEANS.

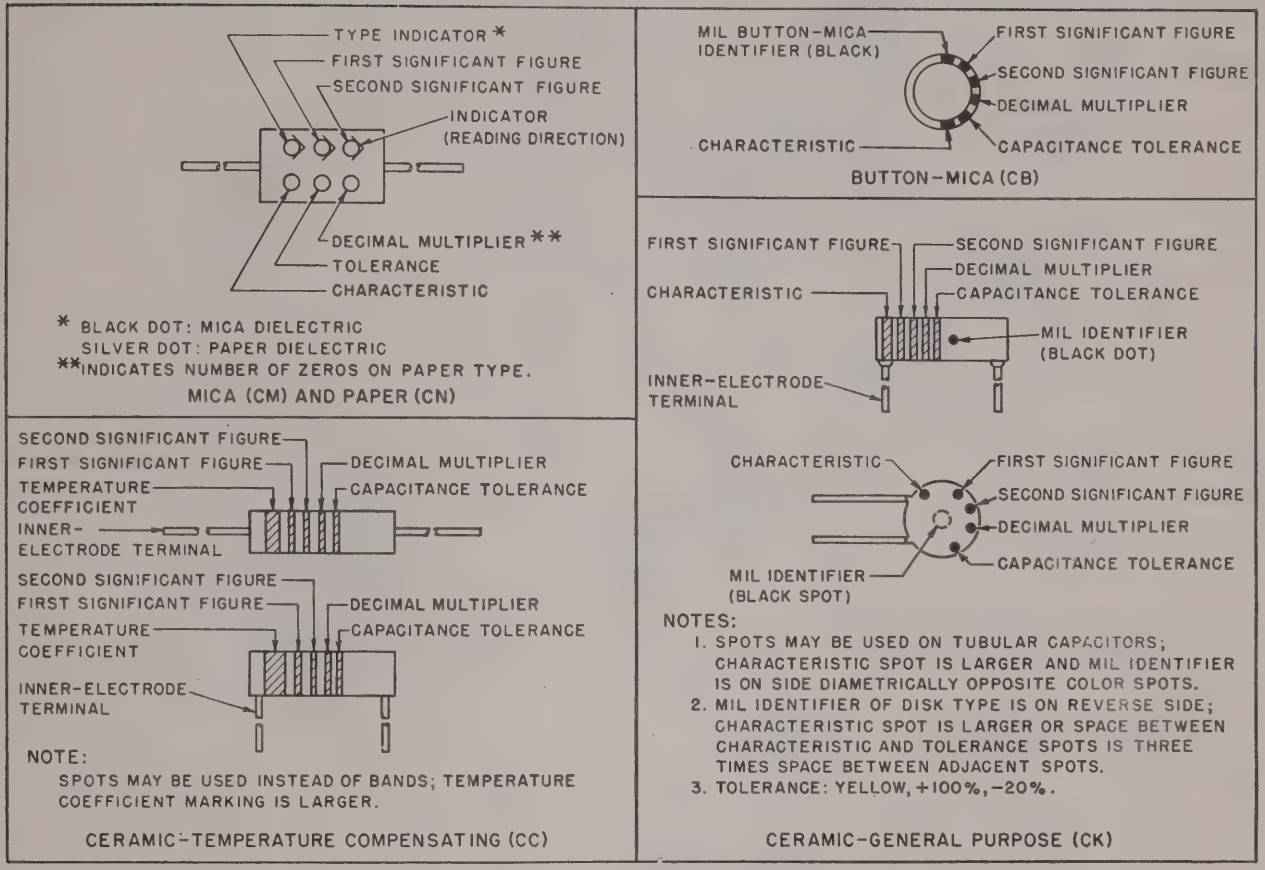
EXAMPLES (BAND MARKING):
10 OHMS ±20 PERCENT: BROWN BAND A; BLACK BAND B; BLACK BAND C; NO BAND D.
4.7 OHMS ±5 PERCENT: YELLOW BAND A; PURPLE BAND B; GOLD BAND C; GOLD BAND D.

EXAMPLES (BODY MARKING):
10 OHMS ±20 PERCENT: BROWN BODY; BLACK END; BLACK DOT OR BAND; BODY COLOR ON TOLERANCE END.
3,000 OHMS ±10 PERCENT: ORANGE BODY; BLACK END; RED DOT OR BAND; SILVER END.

STD-RI

Figure 92. Resistor color codes.

CAPACITOR COLOR CODE MARKING (MIL-STD CAPACITORS)



CAPACITOR COLOR CODE

COLOR	SIG FIG.	MULTIPLIER		CHARACTERISTIC[1]				TOLERANCE[2]					TEMPERATURE COEFFICIENT (UUF/UF/°C)
		DECIMAL	NUMBER OF ZEROS	CM	CN	CB	CK	CM	CN	CB	CC		
											OVER 10UUF	10UUF OR LESS	CC
BLACK	0	1	NONE		A			20	20	20	20	2	ZERO
BROWN	1	10	1	B	E	B	W				1		-30
RED	2	100	2	C	H		X	2		2	2		-80
ORANGE	3	1,000	3	D	J	D			30				-150
YELLOW	4	10,000	4	E	P								-220
GREEN	5		5	F	R						5	0.5	-330
BLUE	6		6		S								-470
PURPLE (VIOLET)	7		7		T	W							-750
GRAY	8		8			X						0.25	+30
WHITE	9		9								10	1	-330(±500)[3]
GOLD		0.1						5		5			+100
SILVER		0.01						10	10	10			

1. LETTERS ARE IN TYPE DESIGNATIONS GIVEN IN MIL-C SPECIFICATIONS.
2. IN PERCENT, EXCEPT IN UUF FOR CC-TYPE CAPACITORS OF 10 UUF OR LESS.
3. INTENDED FOR USE IN CIRCUITS NOT REQUIRING COMPENSATION.

STD-CI

Figure 93. Capacitor color codes.

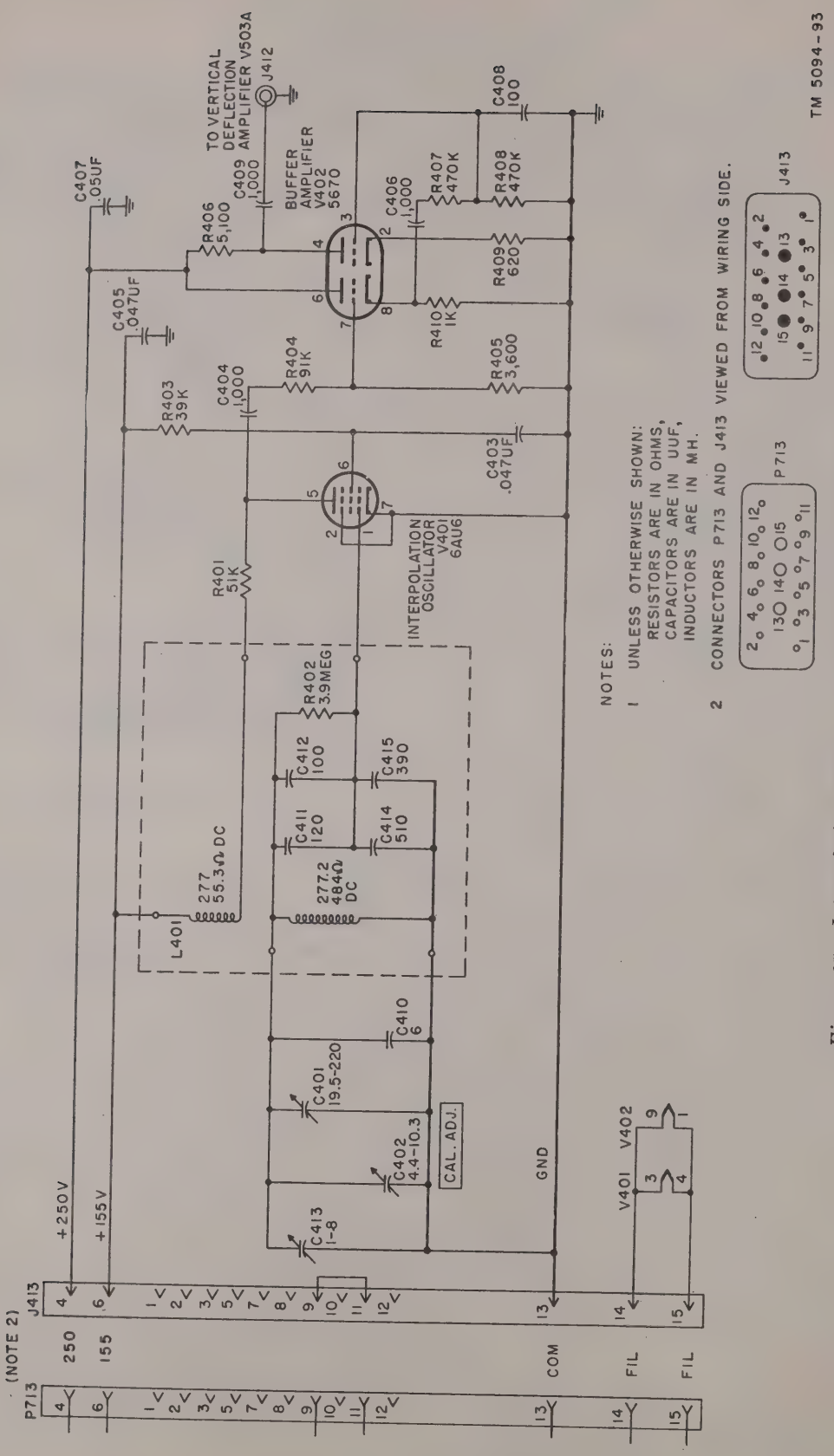


Figure 97. Interpolation oscillator subchassis, schematic diagram.

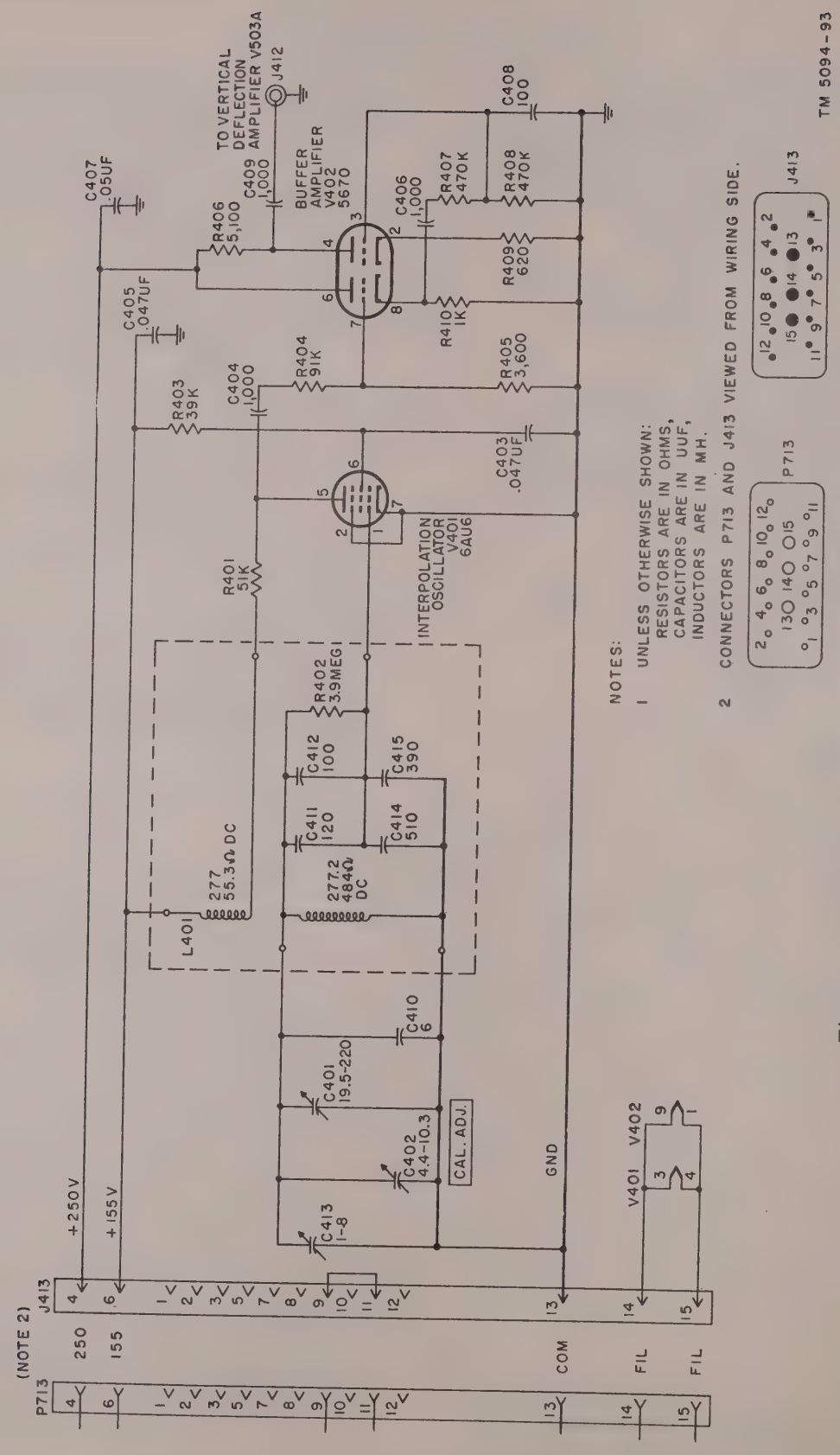
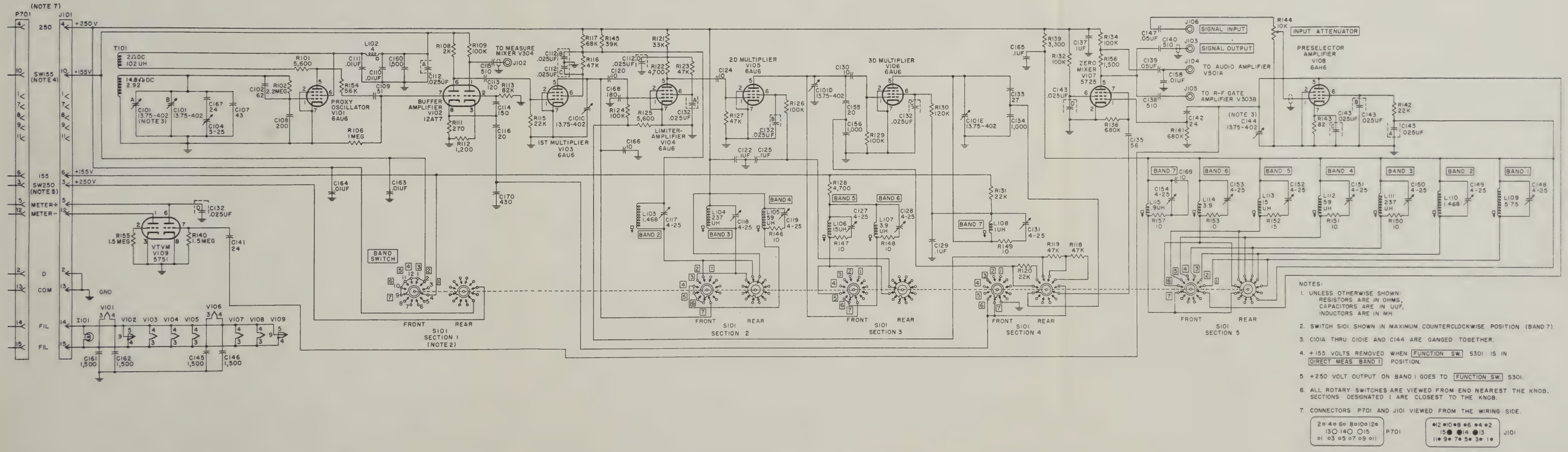


Figure 97. Interpolation oscillator subchassis, schematic diagram.

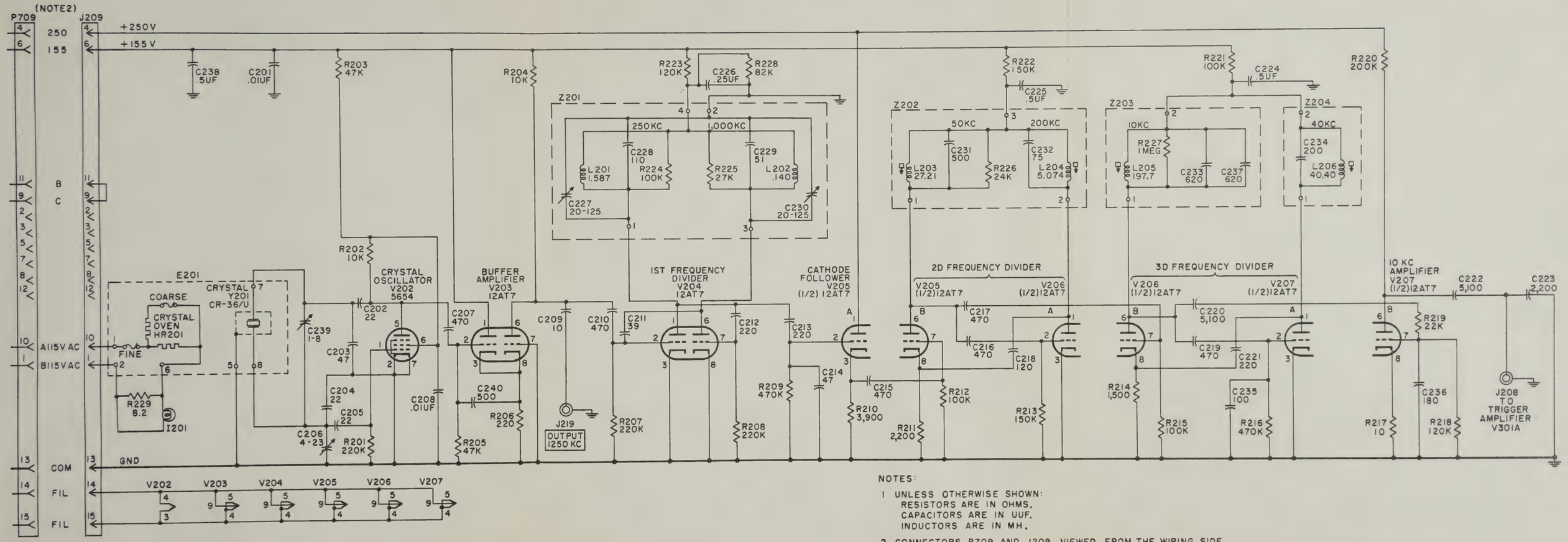


NOTES:

1. UNLESS OTHERWISE SHOWN: RESISTORS ARE IN OHMS, CAPACITORS ARE IN UUF, INDUCTORS ARE IN MH.
2. SWITCH S101 SHOWN IN MAXIMUM COUNTERCLOCKWISE POSITION (BAND 7).
3. C101A THRU C101E AND C144 ARE GANGED TOGETHER.
4. +155 VOLTS REMOVED WHEN FUNCTION SW. S301 IS IN DIRECT MEAS BAND 1 POSITION.
5. +250 VOLT OUTPUT ON BAND 1 GOES TO FUNCTION SW. S301.
6. ALL ROTARY SWITCHES ARE VIEWED FROM END NEAREST THE KNOB. SECTIONS DESIGNATED 1 ARE CLOSEST TO THE KNOB.
7. CONNECTORS P701 AND J101 VIEWED FROM THE WIRING SIDE.

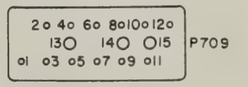
Figure 84. Proxy oscillator-multiplier subchassis, schematic diagram.

327532 O - 53



NOTES:

1. UNLESS OTHERWISE SHOWN:
   RESISTORS ARE IN OHMS.
   CAPACITORS ARE IN UUF.
   INDUCTORS ARE IN MH.
2. CONNECTORS P709 AND J209 VIEWED FROM THE WIRING SIDE.



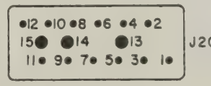


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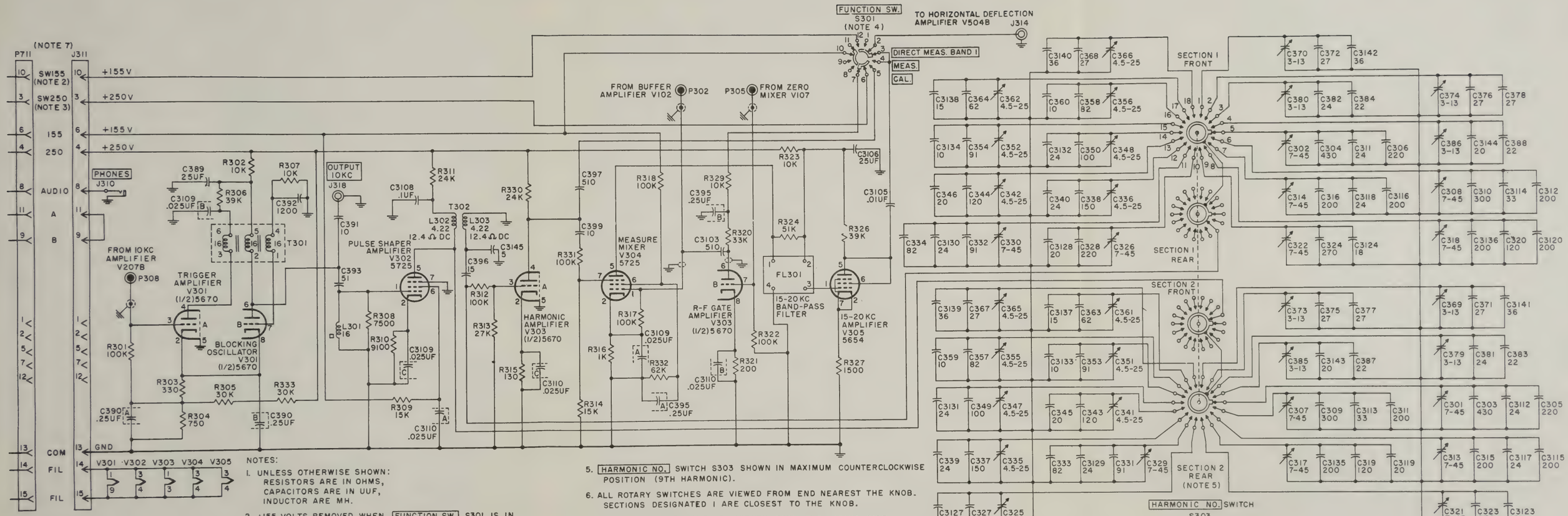
Figure 95. Crystal oscillator-divider subchassis, schematic diagram.



NOTES:

1. UNLESS OTHERWISE SHOWN: RESISTORS ARE IN OHMS, CAPACITORS ARE IN UUF, INDUCTOR ARE MH.
2. +155 VOLTS REMOVED WHEN FUNCTION SW. S301 IS IN DIRECT MEAS. BAND I POSITION.
3. +250 VOLT OUTPUT ON BAND I, GOES TO FUNCTION SW. S301.
4. FUNCTION SW. S301 SHOWN IN MAXIMUM COUNTERCLOCKWISE POSITION DIRECT MEAS. BAND I
5. HARMONIC NO. SWITCH S303 SHOWN IN MAXIMUM COUNTERCLOCKWISE POSITION (9TH HARMONIC).
6. ALL ROTARY SWITCHES ARE VIEWED FROM END NEAREST THE KNOB. SECTIONS DESIGNATED I ARE CLOSEST TO THE KNOB.
7. CONNECTORS P711 AND J311 VIEWED FROM THE WIRING SIDE.

Figure 96. Harmonic selector subchassis, schematic diagram.

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[AG413.44 (26 Nov 54)]

BY ORDER OF THE SECRETARIES OF THE ARMY AND THE AIR FORCE:

M. B. RIDGWAY,
General, United States Army,
Chief of Staff.

OFFICIAL:
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The Adjutant General.

N. F. TWINING,
Chief of Staff, United States Air Force.

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NG: None.
USAR: None.
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For explanation of abbreviations used, see SR 320-50-1.

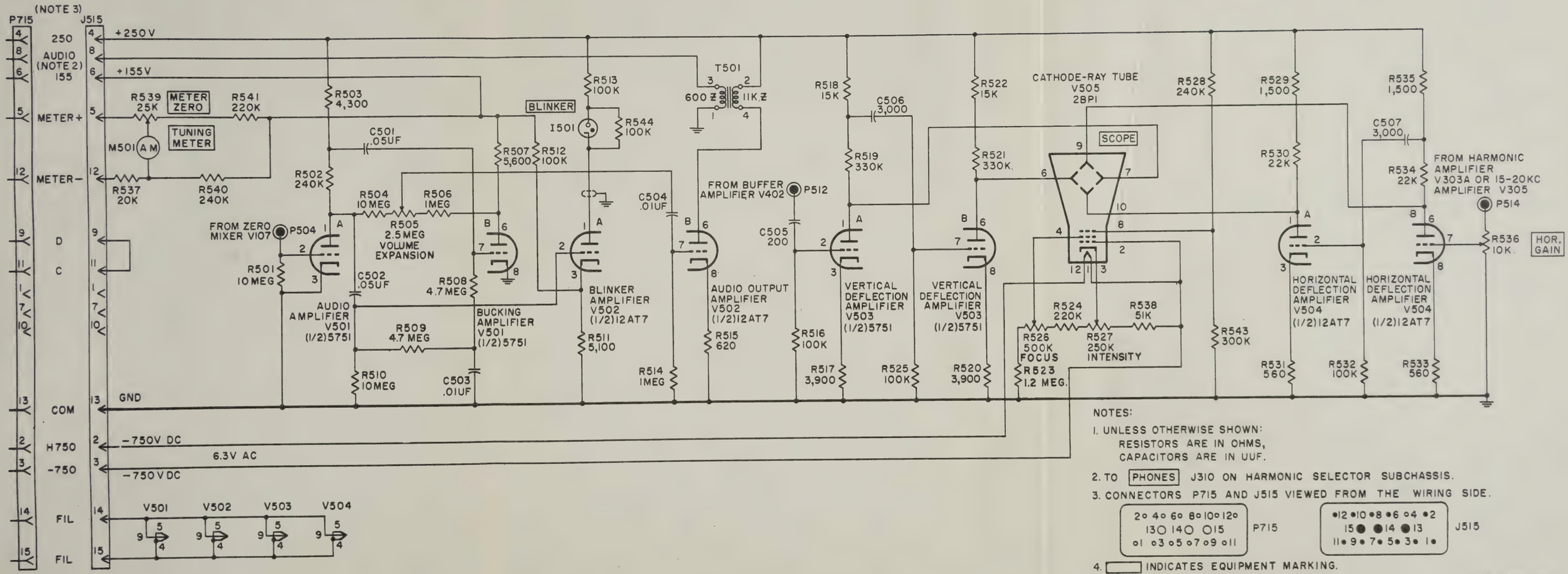

Figure 98. Indicator subchassis, schematic diagram.

NOTES:

1. UNLESS OTHERWISE SHOWN: RESISTORS ARE IN OHMS, CAPACITORS ARE IN UUF.
2. TO [PHONES] J310 ON HARMONIC SELECTOR SUBCHASSIS.
3. CONNECTORS P715 AND J515 VIEWED FROM THE WIRING SIDE.

P715: 2 4 6 8 10 12 / 13 14 15 / 1 3 5 7 9 11

J515: 12 10 8 6 4 2 / 15 14 13 / 11 9 7 5 3 1

4. [ ] INDICATES EQUIPMENT MARKING.

TM 5094-94

327532 O - 55

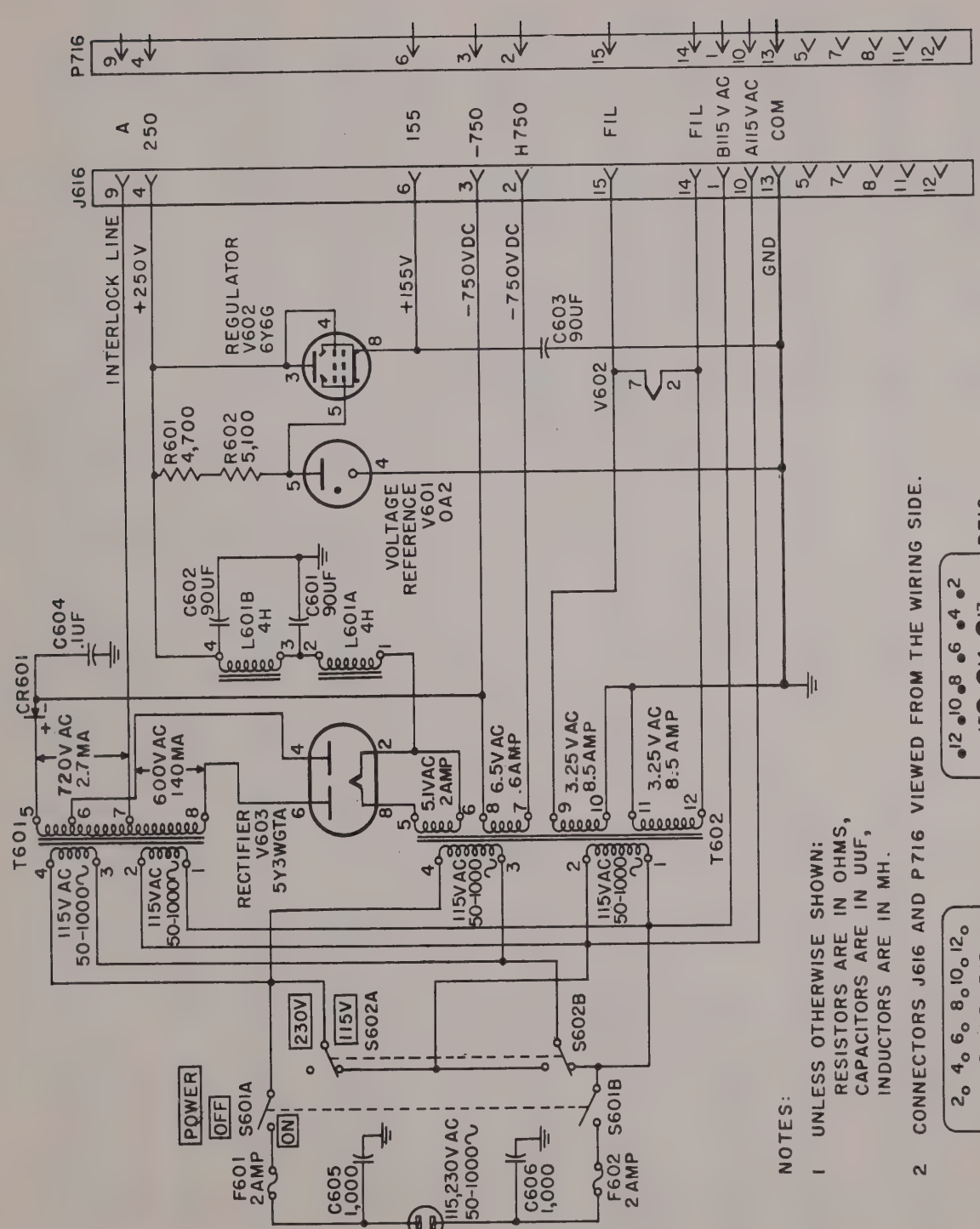

Figure 99. Power supply subchassis, schematic diagram.

4,690 — 4,759 Cycles
5,310 — 5,241 Cycles
* *

	Band 1		Band 2		Band 3		Band 4		Band 5		Band 6		Band 7	
	Freq.		Freq.		Freq.		Freq.		Freq.		Freq.		Freq.	
Dial Div.	Cycles	Cycles	Cycles	Cycles	Cycles	Cycles	Cycles	Cycles	Cycles	Cycles	Cycles	Cycles	Cycles	Cycles
0280.9	4,690	5,310	9,380	10,620	23,450	26,550	46,900	53,100	93,800	106,200	187,600	212,400	375,200	424,800
0280.3	4,691	5,309	9,382	10,618	23,455	26,545	46,910	53,090	93,820	106,180	187,640	212,360	375,280	424,720
0279.8	4,692	5,308	9,384	10,616	23,460	26,540	46,920	53,080	93,840	106,160	187,680	212,320	375,360	424,640
0279.2	4,693	5,307	9,386	10,614	23,465	26,535	46,930	53,070	93,860	106,140	187,720	212,280	375,440	424,560
0278.6	4,694	5,306	9,388	10,612	23,470	26,530	46,940	53,060	93,880	106,120	187,760	212,240	375,520	424,480
0278.1	4,695	5,305	9,390	10,610	23,475	26,525	46,950	53,050	93,900	106,100	187,800	212,200	375,600	424,400
0277.5	4,696	5,304	9,392	10,608	23,480	26,520	46,960	53,040	93,920	106,080	187,840	212,160	375,680	424,320
0276.9	4,697	5,303	9,394	10,606	23,485	26,515	46,970	53,030	93,940	106,060	187,880	212,120	375,760	424,240
0276.4	4,698	5,302	9,396	10,604	23,490	26,510	46,980	53,020	93,960	106,040	187,920	212,080	375,840	424,160
0275.8	4,699	5,301	9,398	10,602	23,495	26,505	46,990	53,010	93,980	106,020	187,960	212,040	375,920	424,080
0275.2	4,700	5,300	9,400	10,600	23,500	26,500	47,000	53,000	94,000	106,000	188,000	212,000	376,000	424,000
0274.6	4,701	5,299	9,402	10,598	23,505	26,495	47,010	52,990	94,020	105,980	188,040	211,960	376,080	423,920
0274.1	4,702	5,298	9,404	10,596	23,510	26,490	47,020	52,980	94,040	105,960	188,080	211,920	376,160	423,840
0273.5	4,703	5,297	9,406	10,594	23,515	26,485	47,030	52,970	94,060	105,940	188,120	211,880	376,240	423,760
0273.0	4,704	5,296	9,408	10,592	23,520	26,480	47,040	52,960	94,080	105,920	188,160	211,840	376,320	423,680
0272.4	4,705	5,295	9,410	10,590	23,525	26,475	47,050	52,950	94,100	105,900	188,200	211,800	376,400	423,600
0271.8	4,706	5,294	9,412	10,588	23,530	26,470	47,060	52,940	94,120	105,880	188,240	211,760	376,480	423,520
0271.3	4,707	5,293	9,414	10,586	23,535	26,465	47,070	52,930	94,140	105,860	188,280	211,720	376,560	423,440
0270.7	4,708	5,292	9,416	10,584	23,540	26,460	47,080	52,920	94,160	105,840	188,320	211,680	376,640	423,360
0270.2	4,709	5,291	9,418	10,582	23,545	26,455	47,090	52,910	94,180	105,820	188,360	211,640	376,720	423,280
0269.6	4,710	5,290	9,420	10,580	23,550	26,450	47,100	52,900	94,200	105,800	188,400	211,600	376,800	423,200
0269.0	4,711	5,289	9,422	10,578	23,555	26,445	47,110	52,890	94,220	105,780	188,440	211,560	376,880	423,120
0268.5	4,712	5,288	9,424	10,576	23,560	26,440	47,120	52,880	94,240	105,760	188,480	211,520	376,960	423,040
0267.9	4,713	5,287	9,426	10,574	23,565	26,435	47,130	52,870	94,260	105,740	188,520	211,480	377,040	422,960
0267.3	4,714	5,286	9,428	10,572	23,570	26,430	47,140	52,860	94,280	105,720	188,560	211,440	377,120	422,880
0266.8	4,715	5,285	9,430	10,570	23,575	26,425	47,150	52,850	94,300	105,700	188,600	211,400	377,200	422,800
0266.2	4,716	5,284	9,432	10,568	23,580	26,420	47,160	52,840	94,320	105,680	188,640	211,360	377,280	422,720
0265.6	4,717	5,283	9,434	10,566	23,585	26,415	47,170	52,830	94,340	105,660	188,680	211,320	377,360	422,640
0265.1	4,718	5,282	9,436	10,564	23,590	26,410	47,180	52,820	94,360	105,640	188,720	211,280	377,440	422,560
0264.5	4,719	5,281	9,438	10,562	23,595	26,405	47,190	52,810	94,380	105,620	188,760	211,240	377,520	422,480
0264.0	4,720	5,280	9,440	10,560	23,600	26,400	47,200	52,800	94,400	105,600	188,800	211,200	377,600	422,400
0263.4	4,721	5,279	9,442	10,558	23,605	26,395	47,210	52,790	94,420	105,580	188,840	211,160	377,680	422,320
0262.8	4,722	5,278	9,444	10,556	23,610	26,390	47,220	52,780	94,440	105,560	188,880	211,120	377,760	422,240
0262.3	4,723	5,277	9,446	10,554	23,615	26,385	47,230	52,770	94,460	105,540	188,920	211,080	377,840	422,160
0261.7	4,724	5,276	9,448	10,552	23,620	26,380	47,240	52,760	94,480	105,520	188,960	211,040	377,920	422,080
0261.2	4,725	5,275	9,450	10,550	23,625	26,375	47,250	52,750	94,500	105,500	189,000	211,000	378,000	422,000
0260.6	4,726	5,274	9,452	10,548	23,630	26,370	47,260	52,740	94,520	105,480	189,040	210,960	378,080	421,920
0260.1	4,727	5,273	9,454	10,546	23,635	26,365	47,270	52,730	94,540	105,460	189,080	210,920	378,160	421,840
0259.5	4,728	5,272	9,456	10,544	23,640	26,360	47,280	52,720	94,560	105,440	189,120	210,880	378,240	421,760
0258.9	4,729	5,271	9,458	10,542	23,645	26,355	47,290	52,710	94,580	105,420	189,160	210,840	378,320	421,680
0258.4	4,730	5,270	9,460	10,540	23,650	26,350	47,300	52,700	94,600	105,400	189,200	210,800	378,400	421,600
0257.8	4,731	5,269	9,462	10,538	23,655	26,345	47,310	52,690	94,620	105,380	189,240	210,760	378,480	421,520
0257.3	4,732	5,268	9,464	10,536	23,660	26,340	47,320	52,680	94,640	105,360	189,280	210,720	378,560	421,440
0256.7	4,733	5,267	9,466	10,534	23,665	26,335	47,330	52,670	94,660	105,340	189,320	210,680	378,640	421,360
0256.1	4,734	5,266	9,468	10,532	23,670	26,330	47,340	52,660	94,680	105,320	189,360	210,640	378,720	421,280
0255.6	4,735	5,265	9,470	10,530	23,675	26,325	47,350	52,650	94,700	105,300	189,400	210,600	378,800	421,200
0255.0	4,736	5,264	9,472	10,528	23,680	26,320	47,360	52,640	94,720	105,280	189,440	210,560	378,880	421,120
0254.5	4,737	5,263	9,474	10,526	23,685	26,315	47,370	52,630	94,740	105,260	189,480	210,520	378,960	421,040
0253.9	4,738	5,262	9,476	10,524	23,690	26,310	47,380	52,620	94,760	105,240	189,520	210,480	379,040	420,960
0253.3	4,739	5,261	9,478	10,522	23,695	26,305	47,390	52,610	94,780	105,220	189,560	210,440	379,120	420,880
0252.8	4,740	5,260	9,480	10,520	23,700	26,300	47,400	52,600	94,800	105,200	189,600	210,400	379,200	420,800
0252.2	4,741	5,259	9,482	10,518	23,705	26,295	47,410	52,590	94,820	105,180	189,640	210,360	379,280	420,720
0251.6	4,742	5,258	9,484	10,516	23,710	26,290	47,420	52,580	94,840	105,160	189,680	210,320	379,360	420,640
0251.1	4,743	5,257	9,486	10,514	23,715	26,285	47,430	52,570	94,860	105,140	189,720	210,280	379,440	420,560
0250.5	4,744	5,256	9,488	10,512	23,720	26,280	47,440	52,560	94,880	105,120	189,760	210,240	379,520	420,480
0249.9	4,745	5,255	9,490	10,510	23,725	26,275	47,450	52,550	94,900	105,100	189,800	210,200	379,600	420,400
0249.4	4,746	5,254	9,492	10,508	23,730	26,270	47,460	52,540	94,920	105,080	189,840	210,160	379,680	420,320
0248.8	4,747	5,253	9,494	10,506	23,735	26,265	47,470	52,530	94,940	105,060	189,880	210,120	379,760	420,240
0248.3	4,748	5,252	9,496	10,504	23,740	26,260	47,480	52,520	94,960	105,040	189,920	210,080	379,840	420,160
0247.6	4,749	5,251	9,498	10,502	23,745	26,255	47,490	52,510	94,980	105,020	189,960	210,040	379,920	420,080
0247.1	4,750	5,250	9,500	10,500	23,750	26,250	47,500	52,500	95,000	105,000	190,000	210,000	380,000	420,000
0246.5	4,751	5,249	9,502	10,498	23,755	26,245	47,510	52,490	95,020	104,980	190,040	209,960	380,080	419,920
0246.0	4,752	5,248	9,504	10,496	23,760	26,240	47,520	52,480	95,040	104,960	190,080	209,920	380,160	419,840
0245.4	4,753	5,247	9,506	10,494	23,765	26,235	47,530	52,470	95,060	104,940	190,120	209,880	380,240	419,760
0244.8	4,754	5,246	9,508	10,492	23,770	26,230	47,540	52,460	95,080	104,920	190,160	209,840	380,320	419,680
0244.3	4,755	5,245	9,510	10,490	23,775	26,225	47,550	52,450	95,100	104,900	190,200	209,800	380,400	419,600
0243.7	4,756	5,244	9,512	10,488	23,780	26,220	47,560	52,440	95,120	104,880	190,240	209,760	380,480	419,520
0243.2	4,757	5,243	9,514	10,486	23,785	26,215	47,570	52,430	95,140	104,860	190,280	209,720	380,560	419,440
0242.6	4,758	5,242	9,516	10,484	23,790	26,210	47,580	52,420	95,160	104,840	190,320	209,680	380,640	419,360
0242.0	4,759	5,241	9,518	10,482	23,795	26,205	47,590	52,410	95,180	104,820	190,360	209,640	380,720	419,280
		*		*		*		*		*		*		*

* DENOTES RED COLUMN

CRYSTAL CHECK POINT DIAL DIV. 0294.1 (*)
PATTERN RATIO: 15/1 HARMONIC NUMBER: 23

TM5094-100

Figure 101. Typical page of calibration book.

4,690 — 4,759 Cycles
5,310 — 5,241 Cycles
* *

Dial Div.	Band 1 Freq. Cycles	Band 1 Freq. Cycles	Band 2 Freq. Cycles	Band 2 Freq. Cycles	Band 3 Freq. Cycles	Band 3 Freq. Cycles	Band 4 Freq. Cycles	Band 4 Freq. Cycles	Band 5 Freq. Cycles	Band 5 Freq. Cycles	Band 6 Freq. Cycles	Band 6 Freq. Cycles	Band 7 Freq. Cycles	Band 7 Freq. Cycles
0280.9	4,690	5,310	9,380	10,620	23,450	26,550	46,900	53,100	93,800	106,200	187,600	212,400	375,200	424,800
0280.3	4,691	5,309	9,382	10,618	23,455	26,545	46,910	53,090	93,820	106,180	187,640	212,360	375,280	424,720
0279.8	4,692	5,308	9,384	10,616	23,460	26,540	46,920	53,080	93,840	106,160	187,680	212,320	375,360	424,640
0279.2	4,693	5,307	9,386	10,614	23,465	26,535	46,930	53,070	93,860	106,140	187,720	212,280	375,440	424,560
0278.6	4,694	5,306	9,388	10,612	23,470	26,530	46,940	53,060	93,880	106,120	187,760	212,240	375,520	424,480
0278.1	4,695	5,305	9,390	10,610	23,475	26,525	46,950	53,050	93,900	106,100	187,800	212,200	375,600	424,400
0277.5	4,696	5,304	9,392	10,608	23,480	26,520	46,960	53,040	93,920	106,080	187,840	212,160	375,680	424,320
0276.9	4,697	5,303	9,394	10,606	23,485	26,515	46,970	53,030	93,940	106,060	187,880	212,120	375,760	424,240
0276.4	4,698	5,302	9,396	10,604	23,490	26,510	46,980	53,020	93,960	106,040	187,920	212,080	375,840	424,160
0275.8	4,699	5,301	9,398	10,602	23,495	26,505	46,990	53,010	93,980	106,020	187,960	212,040	375,920	424,080
0275.2	4,700	5,300	9,400	10,600	23,500	26,500	47,000	53,000	94,000	106,000	188,000	212,000	376,000	424,000
0274.6	4,701	5,299	9,402	10,598	23,505	26,495	47,010	52,990	94,020	105,980	188,040	211,960	376,080	423,920
0274.1	4,702	5,298	9,404	10,596	23,510	26,490	47,020	52,980	94,040	105,960	188,080	211,920	376,160	423,840
0273.5	4,703	5,297	9,406	10,594	23,515	26,485	47,030	52,970	94,060	105,940	188,120	211,880	376,240	423,760
0273.0	4,704	5,296	9,408	10,592	23,520	26,480	47,040	52,960	94,080	105,920	188,160	211,840	376,320	423,680
0272.4	4,705	5,295	9,410	10,590	23,525	26,475	47,050	52,950	94,100	105,900	188,200	211,800	376,400	423,600
0271.8	4,706	5,294	9,412	10,588	23,530	26,470	47,060	52,940	94,120	105,880	188,240	211,760	376,480	423,520
0271.3	4,707	5,293	9,414	10,586	23,535	26,465	47,070	52,930	94,140	105,860	188,280	211,720	376,560	423,440
0270.7	4,708	5,292	9,416	10,584	23,540	26,460	47,080	52,920	94,160	105,840	188,320	211,680	376,640	423,360
0270.2	4,709	5,291	9,418	10,582	23,545	26,455	47,090	52,910	94,180	105,820	188,360	211,640	376,720	423,280
0269.6	4,710	5,290	9,420	10,580	23,550	26,450	47,100	52,900	94,200	105,800	188,400	211,600	376,800	423,200
0269.0	4,711	5,289	9,422	10,578	23,555	26,445	47,110	52,890	94,220	105,780	188,440	211,560	376,880	423,120
0268.5	4,712	5,288	9,424	10,576	23,560	26,440	47,120	52,880	94,240	105,760	188,480	211,520	376,960	423,040
0267.9	4,713	5,287	9,426	10,574	23,565	26,435	47,130	52,870	94,260	105,740	188,520	211,480	377,040	422,960
0267.3	4,714	5,286	9,428	10,572	23,570	26,430	47,140	52,860	94,280	105,720	188,560	211,440	377,120	422,880
0266.8	4,715	5,285	9,430	10,570	23,575	26,425	47,150	52,850	94,300	105,700	188,600	211,400	377,200	422,800
0266.2	4,716	5,284	9,432	10,568	23,580	26,420	47,160	52,840	94,320	105,680	188,640	211,360	377,280	422,720
0265.6	4,717	5,283	9,434	10,566	23,585	26,415	47,170	52,830	94,340	105,660	188,680	211,320	377,360	422,640
0265.1	4,718	5,282	9,436	10,564	23,590	26,410	47,180	52,820	94,360	105,640	188,720	211,280	377,440	422,560
0264.5	4,719	5,281	9,438	10,562	23,595	26,405	47,190	52,810	94,380	105,620	188,760	211,240	377,520	422,480
0264.0	4,720	5,280	9,440	10,560	23,600	26,400	47,200	52,800	94,400	105,600	188,800	211,200	377,600	422,400
0263.4	4,721	5,279	9,442	10,558	23,605	26,395	47,210	52,790	94,420	105,580	188,840	211,160	377,680	422,320
0262.8	4,722	5,278	9,444	10,556	23,610	26,390	47,220	52,780	94,440	105,560	188,880	211,120	377,760	422,240
0262.3	4,723	5,277	9,446	10,554	23,615	26,385	47,230	52,770	94,460	105,540	188,920	211,080	377,840	422,160
0261.7	4,724	5,276	9,448	10,552	23,620	26,380	47,240	52,760	94,480	105,520	188,960	211,040	377,920	422,080
0261.2	4,725	5,275	9,450	10,550	23,625	26,375	47,250	52,750	94,500	105,500	189,000	211,000	378,000	422,000
0260.6	4,726	5,274	9,452	10,548	23,630	26,370	47,260	52,740	94,520	105,480	189,040	210,960	378,080	421,920
0260.1	4,727	5,273	9,454	10,546	23,635	26,365	47,270	52,730	94,540	105,460	189,080	210,920	378,160	421,840
0259.5	4,728	5,272	9,456	10,544	23,640	26,360	47,280	52,720	94,560	105,440	189,120	210,880	378,240	421,760
0258.9	4,729	5,271	9,458	10,542	23,645	26,355	47,290	52,710	94,580	105,420	189,160	210,840	378,320	421,680
0258.4	4,730	5,270	9,460	10,540	23,650	26,350	47,300	52,700	94,600	105,400	189,200	210,800	378,400	421,600
0257.8	4,731	5,269	9,462	10,538	23,655	26,345	47,310	52,690	94,620	105,380	189,240	210,760	378,480	421,520
0257.3	4,732	5,268	9,464	10,536	23,660	26,340	47,320	52,680	94,640	105,360	189,280	210,720	378,560	421,440
0256.7	4,733	5,267	9,466	10,534	23,665	26,335	47,330	52,670	94,660	105,340	189,320	210,680	378,640	421,360
0256.1	4,734	5,266	9,468	10,532	23,670	26,330	47,340	52,660	94,680	105,320	189,360	210,640	378,720	421,280
0255.6	4,735	5,265	9,470	10,530	23,675	26,325	47,350	52,650	94,700	105,300	189,400	210,600	378,800	421,200
0255.0	4,736	5,264	9,472	10,528	23,680	26,320	47,360	52,640	94,720	105,280	189,440	210,560	378,880	421,120
0254.5	4,737	5,263	9,474	10,526	23,685	26,315	47,370	52,630	94,740	105,260	189,480	210,520	378,960	421,040
0253.9	4,738	5,262	9,476	10,524	23,690	26,310	47,380	52,620	94,760	105,240	189,520	210,480	379,040	420,960
0253.3	4,739	5,261	9,478	10,522	23,695	26,305	47,390	52,610	94,780	105,220	189,560	210,440	379,120	420,880
0252.8	4,740	5,260	9,480	10,520	23,700	26,300	47,400	52,600	94,800	105,200	189,600	210,400	379,200	420,800
0252.2	4,741	5,259	9,482	10,518	23,705	26,295	47,410	52,590	94,820	105,180	189,640	210,360	379,280	420,720
0251.6	4,742	5,258	9,484	10,516	23,710	26,290	47,420	52,580	94,840	105,160	189,680	210,320	379,360	420,640
0251.1	4,743	5,257	9,486	10,514	23,715	26,285	47,430	52,570	94,860	105,140	189,720	210,280	379,440	420,560
0250.5	4,744	5,256	9,488	10,512	23,720	26,280	47,440	52,560	94,880	105,120	189,760	210,240	379,520	420,480
0249.9	4,745	5,255	9,490	10,510	23,725	26,275	47,450	52,550	94,900	105,100	189,800	210,200	379,600	420,400
0249.4	4,746	5,254	9,492	10,508	23,730	26,270	47,460	52,540	94,920	105,080	189,840	210,160	379,680	420,320
0248.8	4,747	5,253	9,494	10,506	23,735	26,265	47,470	52,530	94,940	105,060	189,880	210,120	379,760	420,240
0248.3	4,748	5,252	9,496	10,504	23,740	26,260	47,480	52,520	94,960	105,040	189,920	210,080	379,840	420,160
0247.6	4,749	5,251	9,498	10,502	23,745	26,255	47,490	52,510	94,980	105,020	189,960	210,040	379,920	420,080
0247.1	4,750	5,250	9,500	10,500	23,750	26,250	47,500	52,500	95,000	105,000	190,000	210,000	380,000	420,000
0246.5	4,751	5,249	9,502	10,498	23,755	26,245	47,510	52,490	95,020	104,980	190,040	209,960	380,080	419,920
0246.0	4,752	5,248	9,504	10,496	23,760	26,240	47,520	52,480	95,040	104,960	190,080	209,920	380,160	419,840
0245.4	4,753	5,247	9,506	10,494	23,765	26,235	47,530	52,470	95,060	104,940	190,120	209,880	380,240	419,760
0244.8	4,754	5,246	9,508	10,492	23,770	26,230	47,540	52,460	95,080	104,920	190,160	209,840	380,320	419,680
0244.3	4,755	5,245	9,510	10,490	23,775	26,225	47,550	52,450	95,100	104,900	190,200	209,800	380,400	419,600
0243.7	4,756	5,244	9,512	10,488	23,780	26,220	47,560	52,440	95,120	104,880	190,240	209,760	380,480	419,520
0243.2	4,757	5,243	9,514	10,486	23,785	26,215	47,570	52,430	95,140	104,860	190,280	209,720	380,560	419,440
0242.6	4,758	5,242	9,516	10,484	23,790	26,210	47,580	52,420	95,160	104,840	190,320	209,680	380,640	419,360
0242.0	4,759	5,241	9,518	10,482	23,795	26,205	47,590	52,410	95,180	104,820	190,360	209,640	380,720	419,280
		*		*		*		*		*		*		*

* DENOTES RED COLUMN

CRYSTAL CHECK POINT DIAL DIV. 0294.1 (*)
PATTERN RATIO: 15/1 HARMONIC NUMBER: 23

TM5094-100

Figure 101. Typical page of calibration book.

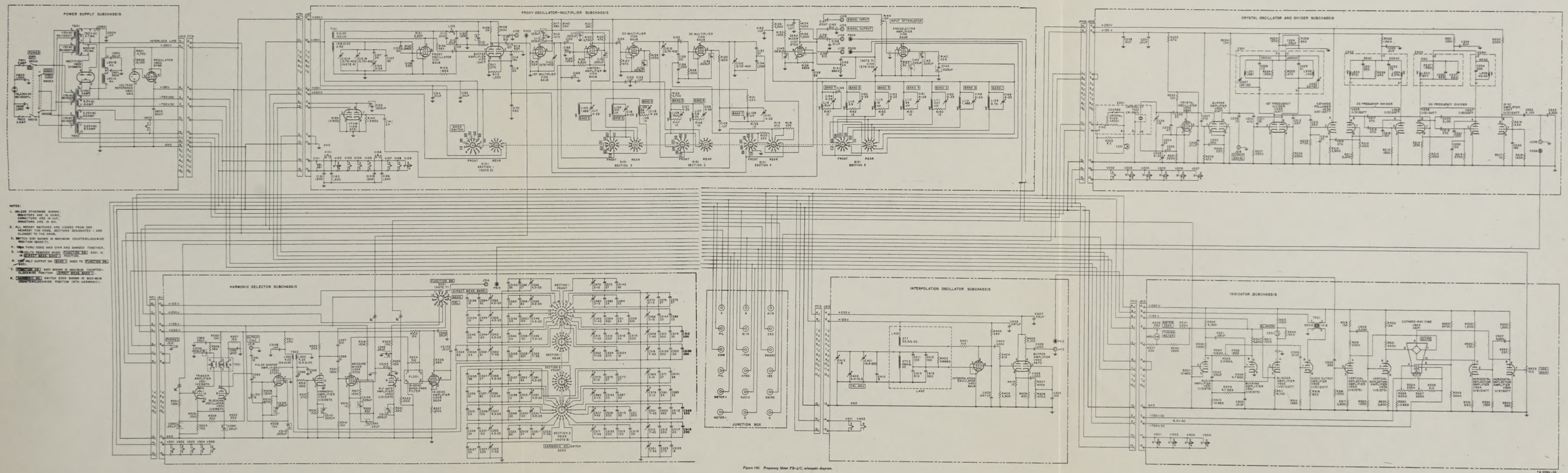

Figure 100. Frequency Meter FR-L/U, schematic diagram.